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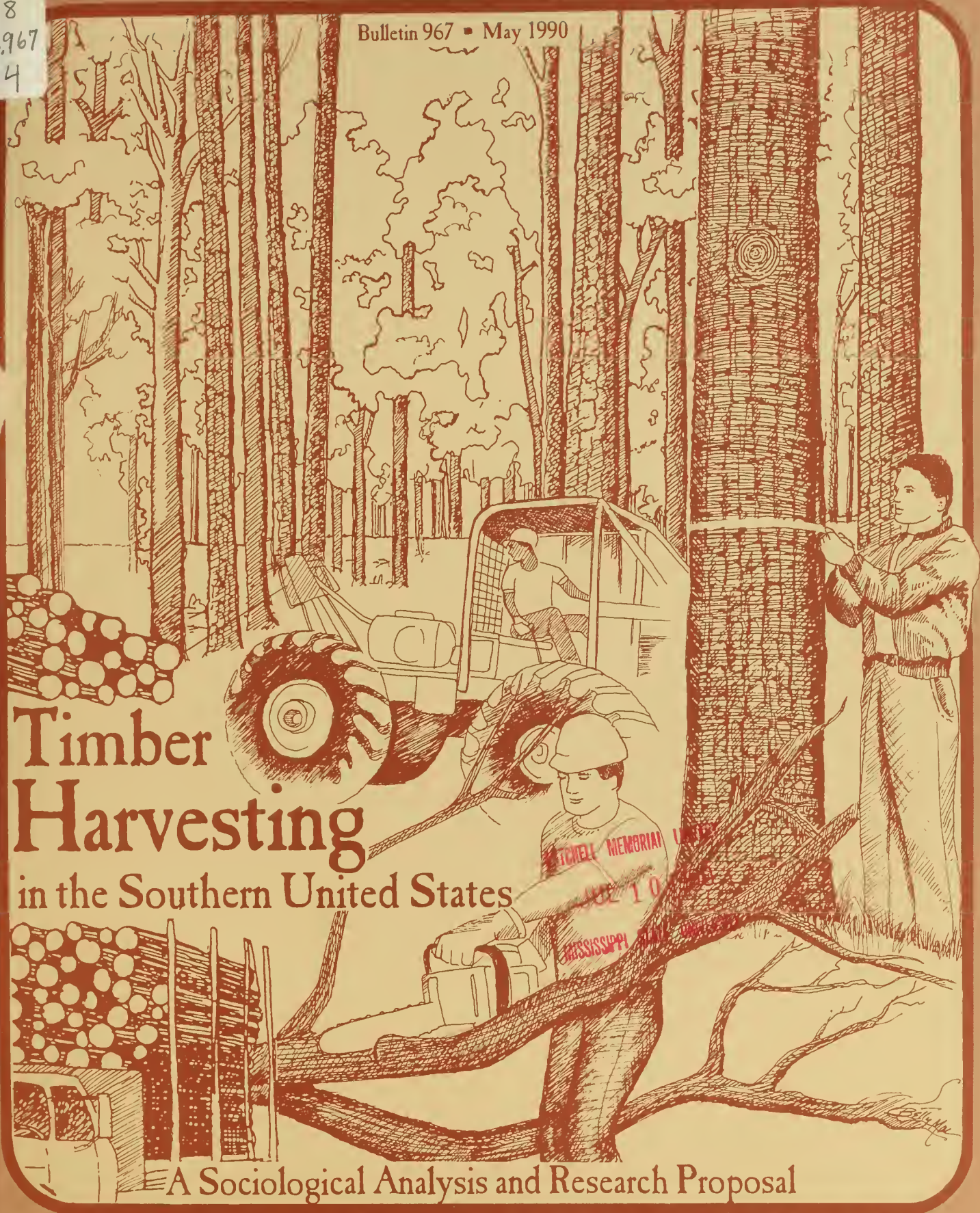

Timber Harvesting in the Southern United States

A Sociological Analysis and Research Proposal

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Timber Harvesting in the Southern United States

A Sociological Analysis and Research Proposal

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Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine.
Edited by Keith H. Remy, Publications Coordinator. Cover designed by Betty Mac Wilson, Artist.

Preface

Until recently, sociology and forestry were considered to be the academic equivalents of oil and water. It is only within the last two or three decades that genuine interdisciplinary research, teaching, and extension endeavors have become institutionalized in universities, research centers, and government agencies. Still, as documented in this bulletin, there is much room for expansion of such endeavors.

Mississippi State University is one of the pioneers in the melding of sociology and forestry. Cooperative research between the Social Science Research Center and the U.S. Department of Agriculture Forest Service has continued uninterrupted since its beginnings in the early 1960's. Faculty from the Departments of Forestry and Sociology have worked together on several research projects and shared the podium in numerous classes.

The assessment of social science research needs in the southern timber harvesting industry reported in this bulletin was conceived and funded by the Forest Products Utilization Laboratory at Mississippi State University under the directorship of Dr. Warren S. Thompson. The Department of Forestry, through its affiliation with the Mississippi Agricultural and Forestry Experiment Station, administered the project and provided general direction. Dr. Douglas P. Richards, Department Head, and Professor William F. Watson participated throughout the assessment by offering their expertise and ideas and acting as sounding boards as the project progressed.

While it is impractical to name all the people in the harvesting industry who contributed to this assessment, three who made significant contributions of their time, experience, and knowledge must be acknowledged: Kenneth S. Rolston, Jr., James A. Altman, and Douglas W. Domenech, all with the American Pulpwood Association. Without their help, this assessment would have been significantly more difficult if not impossible. Dr. Arthur G. Cosby, Director of the Social Science Research Center, and Professor A. W. Baird provided valuable support and consultation from the social science perspective.

This publication is the report of an effort to critically examine timber harvesting in the South from a social science perspective. From the outset, the intent was to provide the industry with information that could be used to help solve some of its problems. Hopefully, the report will be the impetus for a renewed research, development, and application effort in the industry and not simply a dust-gathering curiosity on a few bookshelves.

Larry Doolittle

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Executive Summary

The pivotal position of harvesting in the timber management-marketing-manufacturing process is not matched by the effort devoted to timber harvesting research and development. A group of timber industry consultants recently recommended a 10-year, $13,950,000 research program for the southern harvesting industry alone. (Silversides et al., 1988). One high priority problem area identified by this group was the sociological aspects of harvesting labor. In an effort to more sharply define social science research needs and recommend a research program, an analysis of the southern timber harvesting industry was performed from a sociological perspective. The analysis had four objectives:

(1) document the current state of knowledge about the human behavior aspects of timber harvesting;
(2) identify the nature and relative importance of harvesting problems that are amenable to social science based solutions;
(3) identify the specific specializations within the social science disciplines that should be applied to the various harvesting problems; and
(4) develop a plan for a social science based research program to solve the problems.

Review of the timber harvesting research literature produced little evidence of social science research activity, particularly in the United States. After a promising start by the Battelle Institute and the American Pulpwood Association Harvesting Research Project in the 1960's, social scientists have been almost totally inactive in this subject area. A few investigations of woods worker selection, training, and motivation have been conducted, but the knowledge base pertaining to these aspects of harvesting behavior remains very small.

More progress has been reported outside the United States, especially in Sweden and Finland. Among the accomplishments in those countries are studies of job satisfaction, psychological responses to the work environment, the effects of crew organization on productivity, and work system designs. Whether or not results of these studies are applicable in the U.S. South could be determined only by their replication.

Perusal of the general timber harvesting literature and personal contacts with industry representatives led to the identification of five problem areas that should be the subject of social science research over a 10-year period:

(1) **Individual Workers** — Most behavioral research has focused upon individual woods workers, but the effect of selection, training, and motivation efforts upon individual responses, such as productivity, absenteeism, efficiency, and accidents, has not been systematically evaluated. Also, studies of worker satisfaction, psychological stress, psychological profiles, and leadership traits are needed. Estimated manpower and funding for research in this area are 3 scientist years and $450,000.
(2) **Harvesting Crews** — Group-level variables like norms, values, goals, and interaction patterns should be included as independent variables in evaluation studies. Case studies of the effects of crew organization and operations upon output also are needed. Estimated manpower and funding for this research are 2 scientist years and $300,000.
(3) **The Harvesting Labor Force** — The biggest need in this area is for documentation of labor force characteristics. Periodic surveys can help answer questions about labor sources, qualifications, mobility, turnover, accidents, and other issues as well as provide a basis for trend analysis and projections. Estimated manpower and funding requirements are 1 scientist year and $150,000.
(4) **Structure and Organization of the Harvesting Industry** — Case studies of producer-buyer relationships are needed to determine if there are system variables in the harvesting industry that influence various outcomes. Also, major changes in the structure of the industry, such as the formation of cooperatives or associations, should be documented and evaluated. Estimated manpower and funding are 3 scientist years and $450,000.
(5) **Societal Influences** — Many of the issues facing the southern harvesting industry originate from concerns within the social environment. Macro-level analyses are needed to determine the impact of laws, politics, economic conditions, ecological concerns, and other societal influences upon the harvesting industry. Manpower and funding requirements are estimated to be 1 scientist year and $150,000.

The conceptual framework that seems best suited for providing general direction for the proposed research program is that of the open organizational social system. A wide array of social scientists have participated in organizational research and contributed to an interdisciplinary theory of organizations. Consequently, the literature contains numerous examples of studies focused upon units of analysis from individuals to interorganizational relations. Viewing the harvesting industry as an open system is compatible with the interaction with other social systems and with its general social environment that characterizes the industry. Approached from the open system perspective, the proposed

research program has the potential for making significant contributions to the solution of many of the industry's human behavior related problems.

Implementing the recommended research program will require 10 scientist years and $1.5 million over a 10-year period. Since timber harvesting research efforts in this country have been hampered by a lack of coordination and direction, it is recommended that an appropriately trained social scientist be placed in a university or government research organization to direct and coordinate the program. Among this scientist's responsibilities would be interpretation and application of social science research results for timber harvesting problems; identification of specific research needs and referral of those needs to appropriate specialists for study; consultation to the industry on matters such as training development and evaluation, motivation efforts, crew organization, and accident prevention; and working with technology transfer agencies to assure that research results are disseminated.

Very little data about the logging labor force is systematically collected. Other areas needing attention by social scientists include individual workers, harvesting crews, structure and organization of the industry, and societal influences.

Timber Harvesting in the Southern United States

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Larry Doolittle

Introduction

Timber harvesting occupies a pivotal position in the conversion of standing timber into consumable wood products. In the southern United States,[1] the focal region for this analysis, an estimated 7.5 billion cubic feet of timber valued at $6.1 billion were harvested in 1984 (USDA Forest Service, 1988). In 1987, there were more than 5,600 business establishments engaged in logging; these firms employed nearly 38,000 people and had an annual payroll of almost $522 million (U.S. Department of Commerce Bureau of the Census, 1989).

In spite of the essential nature of timber harvesting, some observers have noted that it is not accorded equal status with either forest production (timber management) or wood processing (Knight, 1985; Shell, 1988b). The impetus for the analysis reported in this document emerged from concern about the disparity in the research resources committed to timber harvesting compared to other forestry subject areas concerned with growing, protecting, and inventorying trees. In 1985, $973,900 and 8.95 scientist years were expended for forest equipment and engineering research in the southern United States (Southern Industrial Forestry Research Council, 1986). These figures were 2.4 percent and 2.9 percent of total expenditures of dollars and scientist years, respectively — the smallest proportions of any of the five subject areas under which research was classified. As an initial step toward rectifying the research inequity, the School of Forest Resources at Mississippi State University sponsored the development of a plan for timber harvesting research in the southern United States. The resulting document (Silversides et al., 1988) identifies research needs in six problem areas and prescribes the manpower and funding requirements for implementing the research program. Under the general problem area of "Labor," a need for sociological research is specified and assigned a high priority. Since there has been virtually no involvement by sociologists in timber harvesting research, and since this is an academic discipline not usually associated with forestry or forest operations, further assessment of the need for sociological (or, more broadly, social science) research was deemed appropriate. Consequently, this paper reports the results of an analysis of the southern timber harvesting industry from a social science perspective.

[1] *Includes the states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.*

Objectives and Procedures

The objectives of this analysis were to:

(1) Document the current state of knowledge about the human behavior aspects of timber harvesting.
(2) Identify the nature and relative importance of harvesting problems that are amenable to social science based solutions.
(3) Identify the specific specializations within the social science disciplines that should be applied to the various harvesting problems.
(4) Develop a plan for a social science based research program to solve the problems.

The general procedures that were employed to meet these objectives were:

(1) Conduct an extensive search and review of the literature pertaining to the behavioral aspects of timber harvesting.
(2) Contact representatives of the harvesting and wood procuring industries and scientists studying other, non-behavioral dimensions of harvesting in an effort to construct a composite account of the problems in harvesting that are behavioral in nature.
(3) Consult social scientists representing the range of specializations that may be appropriate for addressing the problems.
(4) Document the analysis and propose a program of research.

Current State of Knowledge

At the 39th Industrial Forestry Seminar at Yale University in 1974, one of the participants began his presentation as follows: "The study of human factors in logging productivity is still in its infancy. There is almost no published research on this topic in North American logging literature. European work is somewhat farther advanced, but we do not know whether their results are directly applicable here" (Cottell, 1975). Even though research needs were specified and a research program proposed at this same conference (Bond, 1975), a search of the timber harvesting research literature revealed that little progress has been made in the ensuing years. Contributions to the understanding of human behavior as it relates to timber harvesting have been fragmentary, uncoordinated, and widely dispersed, both geographically and conceptually. The resultant literature is elusive; it does not emerge as an entity from either electronic or manual searches. A great many of the titles are in hard-to-locate proceedings, unpublished reports, and foreign journals that often are considered too specialized to be purchased by libraries. A significant volume of the information that does emerge turns out to be empirically based, not scientifically derived, and there is no discernible social science theory or conceptual framework that has guided the scientific undertaking.

In the review that follows, explicit rules for inclusion/exclusion of materials were not set. As near as possible, the included material reported results of systematic inquiry, not isolated incidents, opinion, or "experience," and the inquiry (study, experiment, survey, etc.) was conducted in a timber harvesting setting. Since the ultimate objective of this review is to contribute to the identification of researchable problems, emphasis was placed upon American literature, scant as it is. Literature from other countries is presented primarily as a basis for comparison to help answer the question of what kind of social science investigations should be considered for initiation in the South.

Research in the United States

Studies of human behavior in the U.S. timber harvesting industry have concentrated upon the issue of how to increase productivity. In a harvesting operation, production is a function of two sets of factors — physical and nonphysical (Warren and Raburn, 1975). Physical factors include the machines used, the timber being harvested, the terrain, and the weather. The nonphysical factors are the people who work in the industry. Therefore, raising productivity can be accomplished by introducing new and larger machines or by improving work methods. However, ". . .perhaps the cheapest and most effective [way to increase production]. . .involves motivating each man to his highest potential" (Warren and Raburn, 1975). This conceptualization of the production function was evident from the beginning of social science activity in the timber harvesting arena and has continued to play the lead role in the design and conduct of "human factors" research that has been conducted in this country. Early examples are the Battelle Memorial Institute study from 1960 to 1963 and the American Pulpwood Association Harvesting Research Project from 1967 to 1973.

The Battelle Study — Wood shortages in 1955 and 1959 prompted the southern pulp and paper industry to try to determine why the shortages occurred and how to avoid them in the future. An interdisciplinary research team that included psychologists conducted a comprehensive investigation of the entire pulpwood procurement system, focusing upon the factors affecting production. They found that while production was indeed influenced by site conditions, a factor labeled "crew aggressiveness" was the most important determinant of variations in production (Hamilton, 1963). Crew aggressiveness was defined in terms of a number of factors relating to the producer, the crew, and the work environment (Hamilton and Stock, 1962). Results of these studies led the American Pulpwood Association to initiate a research project with the central purpose of identifying human traits associated with high pulpwood production (Warren and Raburn, 1975).

The Harvesting Research Project — Funded by grants from six wood products companies (later expanded to 15) the Harvesting Research Project (HRP) was initiated in 1967 and headquartered in Atlanta, Georgia (Walbridge, 1972). Though HRP had objectives other than finding ways to increase productivity,[2] it is best remembered for those activities and products. While collecting data about pulpwood crew production, it became obvious that production levels between crews fluctuated even when variables like crew size, equipment, logging site conditions, etc. were identical (Kinne, 1989). Industrial psychologists from the Georgia Institute of Technology were enlisted to investigate this discovery; one, Gary P. Latham, eventually was employed by HRP.

The ultimate purpose of the research conducted by Latham and other psychologists was to develop job performance criteria for the evaluation of independent pulpwood producers in the southern United States (Latham, 1971a). In an effort to determine how successful and unsuccessful producers differed, the researchers first operationally defined "success" in terms of productivity, turnover, absenteeism, and injuries. Then they sorted through a wide array of independent variables, such as the producer's attitude toward his employees, managerial ability, supervisory methods, age, education, experience, marital status, terrain, and equipment (Ronan and Latham, 1969 and 1970). The only important factor to emerge from this analysis was the "producer-worker relationship"; *viz.*, effective producers stayed on the job site, set production goals, gave instructions and explanations, kept tools and equipment in good condition, provided training,

[2] *According to one of the company advisors to HRP, original objectives were to develop production tables for pulpwood crews and to develop a new harvesting machine (Kinne, 1989).*

and "treated their employees as human beings as opposed to objects" (Latham, 1971a). Building upon this finding, the HRP scientists developed an inventory of producer behaviors that were correlated with productivity, turnover, absenteeism, and injuries; ultimately these behaviors were collected into a performance assessment device that pulpwood dealers and company foresters could use in the field to evaluate a producer (Latham, 1971b and 1971c).

In a related but separate analysis, Latham and Kinne investigated the motivations of pulpwood harvesters. After concluding that existing theories of motivation were "inadequate, inapplicable, and/or infeasible" for pulpwood harvesting, the researchers hit upon goal setting as the key to increased production (Latham and Kinne, 1971). However, setting production goals for individual crew members increased productivity only in those crews already found to be "effective"; and, while production goals seemed to lower absenteeism, they had no measurable effect upon turnover or injuries (Latham and Kinne, 1971).

Other social scientists, including a sociologist and an anthropologist, were involved in studies for HRP (Ronan et al., 1970; Bailey and Kim, 1971). These investigations dealt with other aspects of the pulpwood harvesting industry's "labor problem," like sources, qualifications, selection processes, and occupational prestige. In 1973, the HRP was terminated. However, its influence can be detected in subsequent investigations of human behavior factors affecting wood production. Since the days of HRP, behavioral research has focused upon selection, training, and motivation of loggers.

Selection, Training, and Motivation Research — Since cessation of the Battelle and HRP activities, research in the human behavior aspects of timber harvesting has been concentrated more in the Pacific Northwest than in the South (where it originated) and it has been carried out primarily by engineers rather than social scientists.

The screening and selection of loggers has received little attention by research in this country even though there is a pronounced absence of objectivity in these processes (Garland, 1986; Schuh and Kellogg, 1988; Stevenson, 1988). According to Garland (1984), some selection procedures have been validated, but most are are either unpublished or proprietary. There is no indication that objective screening procedures, where they do exist, have been subjected to rigorous evaluation.

Training has received more attention by the harvesting industry than either selection or motivation. Most of the formal training activity originates in either academic institutions or trade associations, like the American Pulpwood Association (APA). Perusal of the literature indicates that the most popular subjects for formal training are safety and business management; there are very few references to *formal* training for equipment operation or maintenance or for personnel management and supervision (Garland, 1984; Schuh and Kellogg, 1988; Stevenson, 1988; Garland, 1979). A recent survey of training needs in the Northeast revealed that 81 percent of the respondents felt that employees should have formal training prior to employment but only 34 percent had even an introductory orientation program for new hires (APA, 1986a). Chain saw operators and skidder operators were the jobs with the greatest need for training according to this survey; however, the *area* of greatest training need was safety.

One account of an attempt to experimentally evaluate a training program was found in the literature, and a second evaluation effort is currently being made. Garland examined the short-term and long-term effects of training for chokersetters in Oregon (Garland, 1982). Evaluative criteria in this experiment included time saved (and, in turn, cost reduction), job leaving, and training cost. Initially there was little difference between the experimental and control groups in performance. During the middle of the experiment, which ran for 6 weeks, the experimental group's performance improved significantly. At the end of the experiment, the control group's performance nearly matched that of the experimental group. The researcher concluded that "the value of training is in the improved learning of the trained group over the group learning on the job."

A second attempt to evaluate a training activity has been conducted in the Southeast (Garland, 1989). This effort employed a before-after case study design, but did not include the experimental controls utilized in the chokersetter study. Published results of this evaluation are not available, but one of the participants described the outcome as "disappointing" (Rolston, 1989).

The high accident rate in logging is a well-documented fact that has received attention in the popular press (Phillips, 1988; Ubell, 1989). In spite of the concern about logging safety in the industry and the emphasis it receives as a subject for training, studies of logging accidents and safety measures are rare. In preparing a background paper for a recent workshop on logging safety, Garland (1988) found only two recent studies of logging accidents". . .worthy of mention." An early exploratory study of risk assessment by chain saw operators found little correlation between operators' estimates of risk and actual risk as reflected by accident rates (Dunn, 1972). Later, Mason (1977), in a British Columbia study, found a low correlation between method of payment and accident frequency; however, pieceworkers suffered more severe accidents than salaried workers.

No discussion of logging accidents and safety training is complete without some reference to the subject of insurance, particularly workers' compensation where rates in the timber harvesting industry reach 50-60 percent of payroll in some southern states (Silversides et al., 1988; APA, 1987). The workers' compensation issue receives a lot of attention in the industry (Stevenson 1989), but very little from research. A project is currently underway at Virginia Polytechnic Institute's (VPI) Industrial Forestry Operations Research Center, where investigators are examining the workers' compensation issue in an effort to develop workable solutions to the problems of "slippage,"[3] insurance rate determination bases, and the absence of physical screening programs for new employees (Wilson, 1988). According to the principal in-

vestigator, this effort is greatly hampered by the lack of reliable data on accidents in the harvesting industry (Stuart, 1989).

Interest in improving the managerial and supervisory skills of wood producers goes back at least to the results of the HRP research. Most extension harvesting specialists in the South include management and/or supervision in their training activities (Brinker, 1989; Deal, 1989; Shaffer, 1989). However, once research established that supervision was an important variable in the production equation, there is no evidence of any subsequent activity directed at training development or evaluation.

The timber harvesting industry has been asking social scientists how to motivate loggers to produce more wood for nearly 30 years (Mayo, 1962; Santopolo, 1962). Incentives ranging from paying bonuses in trading stamps (Altman, 1989) to providing alcohol on the job (Latham, 1989) have been proposed. The landmark research on this subject performed by the HRP has already been reviewed in this report, and there is little work to cite since the producer behavior inventories were developed. Olsen (1988) recently analyzed the performance of five incentive systems for loggers by applying them to a hypothetical yarding operation. He found that each system had its advantages and disadvantages and concluded that if workers are production oriented and the incentive system is well managed, the effects are mostly positive. Even though production gains as high as 39 percent have been documented (Michie, 1983), Garland (1986) concluded that a lack of reliable information about incentive systems hampers their widespread adoption and use in the industry.

Ergonomic and "Human Factors" Research — "Ergonomics is concerned with assuring that machines, task operations, and work environments are designed so that they match human capacities and limitations" (Smith and Sirois, 1982a). In their review of the ergonomic literature as it relates to southern timber harvesting, Smith and Sirois placed the research in this area under five general topics: **(1)** equipment design and maintenance, **(2)** work physiology, **(3)** heat stress, **(4)** vibration and noise stress, and **(5)** safety. The authors, both engineers, did not review research on ". . . other areas of human performance . . . in forest harvesting," such as operator selection and training and psychological stress. Even with those stated restrictions, Smith and Sirois point out that while considerable work in ergonomics has been done in other countries only very limited work has been published by American researchers.

There is evidence that operator safety is a matter of concern to equipment design engineers, as the topic is often discussed at meetings of the American Society of Agricultural Engineers, which has a forest engineering section. Two members of this society recently examined psychological theories concerning the development, analysis, and modification of human behavior and attempted to relate these explanations to an understanding of the effectiveness of safety training (Aherin and Murphy, 1987). These authors concluded that ". . . normal human behavior is often unsafe and to be expected." Consequently, ". . . training humans to practice safe behaviors for the purpose of reducing accidents is the most difficult of any accident prevention measure." No research or development effort was proposed.

The timber harvesting literature contains several references to "human factors" in harvesting (Duncan, 1987). In a presentation to the Human Factors Society, Smith and Sirois (1982b) also reviewed this area of research as it might apply to forest harvesting. As in the case of ergonomic research, there is very little social science based work in this general area, particularly in the United States. Smith and Sirois cited only two studies (Dunn, 1972; Mason, 1977), both of which were described in the section on worker safety in this paper.

Research Outside the United States

In their review of human factors and ergonomics research in forest harvesting, Smith and Sirois (1982a and 1982b) observed that "the countries in which human factors specialists have been most active in forest harvesting research include Sweden, Finland, Norway, Germany, Czechoslovakia, Canada, England, and Japan." The reasons for this disparity between the United States and other developed, forested countries is not at issue here. Neither is it important, for purposes of this paper, to review the specific content of relevant research from around the world — results may or may not be applicable in the U.S. harvesting industry, particularly in the South. Instead, this review will focus upon what scientists from other countries have done in this area that has not been done in the United States. This information will be used later as input for a recommended social science research program in the southern harvesting industry.

At an International Union of Forestry Research Organizations (IUFRO) Congress in 1976, a seminar about psychological and social aspects of forest work was proposed. Organized by the Work Environment Group at the Department of Operational Efficiency, Swedish University of Agricultural Sciences, the seminar was held at Garpenberg, Sweden, in September, 1980. All of the countries (except Japan) mentioned by Smith and Sirios (1982a) were represented by the 27 attendees; no one from the United States attended. The 20 papers presented at the seminar were representative of research on human behavior as it relates to timber harvesting; they were organized into nine "problem areas" (Ager, 1980a)[4]:

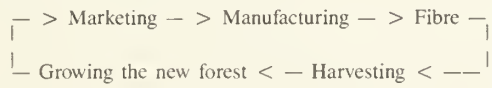
(1) Mental workload (3 papers).
(2) Psychological and social qualities of forest work (4 papers).

[3]*Slippage is the term applied to the failure of some loggers to fully report wood product ion, which is used as a basis for setting insurance rates for pulpwood producers (industrial category 2705); consequently the cost of insurance is spread over a smaller base than it should be with the result of higher rates per producer (Wilson, 1988).*

(3) Work organization (4 papers).
(4) Work supervision (1 paper).
(5) Work system design (5 papers).
(6) Selection of individuals for work (1 paper).
(7) Reward systems (1 paper).
(8) Workers participation in planning and control (1 paper).
(9) Research methods (separate workshop).

By way of comparison, the U.S. Forest Products Research Society and the Canadian Pulp and Paper Association cosponsored a conference at about the same time entitled *"People and Productivity: Keys to a Successful Harvesting Operation"* (Robertson and White, 1984). The 19 papers presented at that conference were organized into four sessions:

(1) Organizing people and machines to optimize productivity in harvesting.
(2) Training and development: people make the system work.
(3) Emerging technologies in harvesting, transportation, and merchandizing.
(4) Closing the circle:



Although the comparison may not be entirely valid, the contents of the two conferences are illustrative of the different directions taken by researchers in the United States and other countries in the past 25 years.

First, researchers outside the U.S. simply have been much more active in the behavioral dimension of harvesting. Any bibliography or reference list pertaining to harvesting will contain more human behavior related work by foreign authors than by Americans. The Scandinavians, in particular, have been much more productive in this field than have the Americans, Canadians, or any other single nationality.[5]

Second, even though foreign scientists continue to look for ways to increase worker productivity, their research is much more likely to include what has been called "job satisfaction" (Bostrand, 1980a; Teikari, 1980; Wilson et al., 1988). From the perspective of the worker, American effort appears to be directed more toward doing something *to* him while foreign effort at least includes doing something *for* him. The fact that there are psychologists involved in the research outside the U.S. may partly account for this shift in research emphasis (Johansson, 1980).

[4]A very similar classification of research activities was made earlier by Bostrand and Frykman (1975) who noted that research in the behavioral aspects of forest work started in Scandinavia in the 1960's — about the same time as the Battelle and HRP research in this country.

[5]Apparently, the propensity of the Nordic countries to conduct social science research in "nontraditional" areas like forestry extends beyond any particular operational area such as harvesting. For an example of "Sociology in Finnish Forest Research," see Young (1980).

Selection, motivation, and training of loggers has received most of the attention by harvesting researchers over ther past several years.

A third comparative observation has to do with the units of analysis employed by the various scientists investigating human behavior in harvesting operations. While American researchers continue to focus upon the individual logger, by the late 1970's scientists from other countries had begun to conduct studies in which the analytical units were work organizations (Frykman, 1980; Kyttala, 1980), work systems (Ager, 1980b; Aminoff and Lindstrom, 1980; Henderson, 1980), and the work environment (Kjellstrand, 1980). Also, more evidence of recognition of the social nature of man can be found in foreign literature than in American literature. That is, while most investigators in this country examine the individual worker only in his or her role as logger (or machine operator, foreman, truck driver, etc.), scientists in other countries are more likely to include other roles or social activities in their analyses of workers; family life and leisure activities (Bostrand, 1980b) and commuting (Bendz, 1967) are examples. Furthermore, the Scandinavians, in particular, are more likely to include personal characteristics, like age, education, and marital status, as independent variables (Hansson, 1965; Makinen, 1988).

Finally, as one might expect, scientists from other countries are more advanced in social science research methods employed in harvesting research. The Swedes and Finns have used questionnaires and personal interviews for a number of years (Gustafsson et al., 1971; Klen, 1977; Lindstrom and Sundstrom-Frisk, 1975; Makinen, 1988), and at the IUFRO workshop were calling for international standardization of research instruments (Ager, 1980b). How much the United States could contribute to such an effort is questionable; since cessation of the HRP research, little has been done in the way of design, application, and improvement of social science research methods.

Evaluation

The most striking feature of the body of literature pertaining to human behavior in timber harvesting is its sparseness. Even the Scandinavians, acknowledged leaders in the field, have not amassed a great store of knowledge on the subject in their 30 years of activity. In the United States, the situation can only be described as dismal. The frontier of knowledge established by the HRP has been advanced only slightly if at all in the past 15 years. Selection, motivation, and training of loggers and supervisors have received most of the attention of harvesting researchers over the past several years. While the evaluation of chokersetter training by Garland (1982) and the incentive system analysis by Olsen (1988) may be prototypal studies of training and motivation, respectively, repetition will be required to prove their value. The absence of a coherent, theory-based research effort to date is only too evident.

Identification of Problems

There is no shortage of opinions about problems in the harvesting industry. More problems are identified than solved in the research literature; the technical literature is replete with implicit and explicit references to gaps in knowledge; trade journals and the popular press contain numerous appeals for problem solving. Moreover, nearly 50 active participants in some aspect of harvesting were personally contacted and quizzed about problems during the conduct of this analysis.

An old adage states that how you stand depends on where you sit. The problems identified by a logger, a procurement officer, an extension specialist, or a scientist reflect his or her particular perspective. The challenge for the analyst is to distinguish between problems that are researchable and problems that are not, to conceptualize the problems at a level of abstraction that lends itself to systematic inquiry, and, finally, to offer a theoretical perspective from which empirical investigations can be deduced and to which findings can be related. The problems in the southern timber harvesting industry that emerged from this analysis and which are behavioral in nature can be placed into five broad areas:

(1) individual workers,
(2) harvesting crews,
(3) the labor force,
(4) structure and organization, and
(5) society.

Individual Workers

Silversides and his colleagues (1988) noted several woodsworker problems in their analysis of research needs. Not surprisingly, most dealt with issues that have been addressed by research over the past 30 years: selecting, training, and motivating individual workers. Specific research needs identified by these analysts are training in efficient, safe, and environmentally sound harvesting methods; increasing the capacity of logging contractors to manage people; and studies and trials of various methods of employee selection. They also noted that training programs for workers should be carefully evaluated and that more effective ways are needed to transfer new knowledge.

Active researchers in the individual worker area are very explicit in their appeal for additional work. Garland, for example, has listed five "appropriate research questions" pertaining to logger training (Garland, 1979) and 14 "potential research areas" in logging safety alone (Garland, 1988). He also feels strongly about the need for "Sound, scientific measures... to confirm (or deny) the gains due to selection, training, and incentive programs" (Garland, 1984). Harvesting equipment design engineers are most concerned about the safety ramifications of "human factors" (Hull and Berry, 1987; Smith and Sorios, 1982a). However, in his overview of human factors concepts, Duncan (1987) lists six examples of equipment design problems whose solutions require knowledge about humans; most require input by physiologists, but some, such as human response to vibration and noise, have psychological aspects as well.

Based upon results of a recent "wants and needs" survey, APA members ranked "10 subject areas which have concerned the pulpwood industry in the past" as follows: workers' compensation, liability insurance, harvesting regulation, stumpage availability, trucking regulation, economy/interest, accidents/injuries, wood demand, independent contractor status, and manpower availability (APA, 1988). The reporters conclude that, "Concerns about insurance do not appear to come hand-in-hand with concerns about accidents/injuries, and the perception that they are not linked appears particularly strong among loggers." The fact appears to be that accident rates and insurance premiums indeed are directly correlated, even though there is a time lag between the two. In a series of articles in a major trade journal, the author reports that reducing accidents is the single best option the logger has for lowering insurance costs (Stevenson, 1989). One major wood supplier in the South saw workers' compensation premiums drop 33 percent over a 9-year period following implementation of an intensive safety program for its producers (Stevenson, 1989).

Assuming that accident prevention through safety training is a major need in the industry, the question of how to deliver the training remains unanswered. The APA survey (1988) showed that 46 percent of the loggers who responded liked the idea of paying $500 to $1,000 to have a trainer spend a day with their employees teaching safe and efficient logging techniques. Among the 54 percent who did not like the idea, approximately equal numbers reported that lack of funds and existing levels of safety and efficiency were reasons for their opposition (APA, 1988). Among nonloggers (wood suppliers, procurement officers, etc.), 67 percent opposed the training idea; nearly one-third of those felt it would be inappropriate

for them to become involved in their contractors' operating methods without jeopardizing the "... appropriate arms-length relationship..." with their contractors (APA, 1988).

This analysis discovered little concern about other aspects of employee selection, motivation, or training from within the industry. Anecdotes exist, to be sure, (like the contractor who hired the only guy that showed up in tennis shoes — the other applicants wore sandals) (Garland, 1984) but they make a shaky foundation for a research program. An informal reader survey conducted by *Timber Harvesting* led to the conclusion that more solid approaches to hiring, training, and motivating employees are needed. However, there was little consensus among respondents about what works and what doesn't (Stevenson, 1988). There is a great deal of training activity in the industry with safety (for woods workers and truck drivers) and business management (for contractors) being prevalent topics. Research plays a very minor role in the development, delivery, or evaluation of this training.

Conclusion: The greatest social science research need in the general problem area of individual workers is the systematic evaluation of selection, training, and motivation (incentive) efforts. Unless programs are evaluated, there can be no objective basis for their continuation, alteration, replacement, or termination. Social scientists have the research tools to conduct scientific evaluation of programs that aim to alter human behavior. Failure to employ those tools to evaluate programs like truck driver training (Rolston, 1986) and tailgate logging safety (APA, undated) means continuing the current practice of appraising programs upon the basis of appearances, opinions, and isolated observations.

Other opportunities for social science research are in the areas of job satisfaction, psychological responses to the work environment (including harvesting machines), worker profile development, and leadership studies. A good foundation for research in these areas has been lain, particularly in the Scandinavian countries and, in worker profiles, in Canada (Sarna, 1977). Furthermore, the general industrial psychology literature is a rich source of pertinent information (see, for example, Locke, 1986; Cooper and Robertson, 1986; Landy, 1986).

Harvesting Crews

Timber harvesting work crews are more than an aggregation of individuals: they are small social groups which, consequently, possess the defining characteristics of similar norms, values, and expectations and regular, conscious interaction (Schafer, 1989). Groups have structure (statuses and roles), and they are goal oriented. The relationship between an individual and groups to which he or she belongs is reciprocal; that is, each influences the other.

Although economists have treated the timber harvesting crew as the basic unit of production, it has been almost totally ignored as a unit of analysis by other harvesting researchers. In perhaps the only direct reference to a crew-level

Logging crews are more than an aggregation of individuals; they are small social groups as well.

characteristic in the American research literature, the Battelle group identified "crew aggressiveness" as an important factor in pulpwood production (Hamilton and Stock, 1962). Aggressiveness was further defined in terms of several more specific variables: planning and job flexibility, performance standards, crew responsibility for safety and equipment maintenance, leadership, production goals, and production incentives. Although later studies, including those conducted by HRP, have identified some of these same variables as production factors, all have treated them as characteristics of individual workers. The role that social (group) influences may play in productivity, safety, efficiency, and other crew "outputs" simply has never been explored in the timber harvesting industry although the importance of such influences in an industrial setting was discovered by social scientists 50 years ago (Roethlisberger and Dickson, 1939).

The Swedes and Finns have been somewhat more active in the area of work organization, including crew-level studies (see Frykman, 1980, and Kyttala, 1978, as examples.) The work environment research group in the Department of Operational Efficiency, College of Forestry, Swedish University of Agricultural Sciences, has been following and evaluating logging crews with different work organization forms since 1975. The composition of the work team and the role of supervisors have emerged as critical factors in crew production and efficiency (Frykman, 1980).

The technical literature and trade and popular media are nearly as mute as the research literature on the subject of logging crew organization and operations. A technical paper from the northeastern United States describes results of a survey of seven logging crews to identify the characteristics of a "safe and efficient" crew (APA, 1985). Two key elements were identified: worker attitude and knowledge of planning and work procedures. This report also includes brief descriptions of two of the crews that were surveyed; other than "teamwork," no group phenomena were included in the description.

The only specific appeal for research in this problem area that could be found in the American literature was made 15 years ago. In his comprehensive assessment of research needs in timber harvesting labor, Bond (1975) included "interpersonal relations" among his eight problem areas and specified worker-worker, worker-supervisor, and worker-machine as examples. The very ambitious research program outlined by Bond has not become reality.

Harvesting industry representatives contacted during the course of this analysis did not specify any problems related directly to logging crew organization and/or operations; traditional worker issues (selection, training, motivation) are perceived as individual, not crew level, problems.

Conclusion: The independent nature and variability of the logging force in the United States, and the fact that nearly all of the social science involvement has been by psychologists, have combined to discourage behavioral research at the group (crew) level. Consequently, a potentially important source of variation in productivity, accident rates, turnover, absenteeism, etc. has not been analyzed. Future studies of these "output" phenomena should include norms, values, goals, and interaction patterns at the crew level as independent variables. Furthermore, evaluation studies, described under the "individual worker" problem area, should examine group phenomena as possible explanations for why the same program produces different results in separate but similar crews.

Experimental manipulation of crew organization, work assignment, work schedules, etc. could produce significant results, as it has in Scandinavia (Bostrand, 1980b; Frykman, 1980). However, the nature of the harvesting industry in the South makes the conduct of such studies highly unlikely. An alternative approach would be to identify existing logging crews that collectively possess variations in organizational and operational features and conduct comparative case studies in an effort to identify both individual and group variables that influence outcomes.

The Labor Force

In his assessment of research needs in forest labor, Bond (1975) noted several problems related to the harvesting labor force: competition from alternative job opportunities; how to attract workers; the desired character of future laborers; the image of woods labor. Apparently, there has been very little response to Bond's appeal for research in this area. The timber harvesting research literature is nearly devoid of studies of labor force issues or even documentations of labor force characteristics. Most labor force issues are addressed from the individual worker perspective; that is, problems like employee selection, motivation, and training are defined as labor force problems but analyzed at the individual worker level (Garland, 1984 and 1986). This approach ignores the possibility that some issues, such as manpower availability, occupational prestige or image, turnover rates, age structure, educational attainment, and geographic distribution, should be (or, in some cases, can *only* be) examined at the labor force level.

Within the industry itself, the labor problem most often mentioned is that of manpower availability, or, "How to find forest workers and keep them on the job" (Bryan, 1981). Results of APA's "wants and needs" survey showed 77 percent of the respondents agreeing that "availability of harvesting manpower will be more of a problem in 5 years than it is now" (APA, 1988). While mechanization has shifted the industry away from its once near total reliance upon labor, there is now a sense of uneasiness about the availability of *qualified* labor: 53 percent of APA's respondents agreed that "mechanization will make qualified harvesting workers harder to find over the coming 5 years" (APA, 1988). As machines become more and more sophisticated and complex to operate and maintain, loggers and wood procurement foresters worry about where the operators will come from (Manz, 1988; Griffin, 1988).

Conclusion: The biggest single need in this problem area is for documentation of labor force characteristics. Other than

The timber harvesting industry can be viewed as a social system that regularly interacts with other systems, particularly tree growers and wood buyers/processors.

general data from Bureau of Labor Statistics and Bureau of Census reports, there is no source of systematic, detailed information about the logging labor force. In the South, the periodic "producer surveys"[6] sponsored by the APA provide a modest amount of information about pulpwood contractors, like age, education, and number of employees (Watson et al., 1989). APA should give serious consideration to including provision for collecting more detailed data about all workers in the harvesting industry in subsequent surveys of this type. Periodic descriptions of worker characteristics would either substantiate or refute some of the fears concerning skilled labor shortages and provide a basis for projecting trends into the future.[7]

Labor force studies also have the potential for producing answers to questions about worker sources, turnover, mobility (within the industry and between harvesting and other industries), job satisfaction, occupational prestige, accidents and near accidents, and a host of others that concern the industry from time to time. Modern survey techniques allow results to be produced in a matter of days or even hours, depending upon the size of the sample. There is simply no good reason for the harvesting industry to remain in the dark about its own manpower.

Structure and Organization of the Harvesting Industry

Just as harvesting crews can be viewed as social groups, the timber harvesting industry can be analyzed as a social system. The defining characteristic of a social system is the interdependence of its parts; that is, a system is composed of a complex of elements in interaction. When applied to large organizations or industries, the focus of systems analysis is upon the relations among the interacting elements (Haas and Drabek, 1973). An "open-system" perspective recognizes that a social system cannot survive in isolation; instead, it must interact with other systems within its environment (Cook, 1977). This perspective seems especially appropriate for the timber harvesting industry. Not only is it composed of a complex of interacting elements (logging contractors, transportation contractors, wood dealers), it also regularly interacts with other social systems, particularly with timberland owners and wood buyers/processors upon which its very survival depends.

The structure and organization of the timber harvesting industry has received very little attention in harvesting research or literature. References to "systems" usually mean silvicultural (Blomquist, 1985), operational (Mattson, 1985), technological (Sturos, 1985), or managerial (Burton, 1985). However, in his opening presentation to the IUFRO seminar cited earlier, Ager (1980b) reviewed a few of the many different conceptualizations of "work design systems," and Kyttala (1980) discussed the organization of logging in Finland at the same seminar. Also, Bond (1975) again must be cited for his insight as he included "the organization of the timber harvesting industry" among the problems potentially affecting the supply of forest labor. He went on to raise the question which remains unanswered: "[Is] the dealer-producer-contractor system . . . at fault," and suggested that ". . . alternatives need to be investigated."

The relationship (or interaction) between timber harvesters (loggers, truckers, wood dealers) and wood buyers/processors (sawmills, paper mills, etc.) is frequently discussed, but it has not been the object of systematic study. It is a complex phenomenon; there are legal considerations (Granskog and Siegel, 1978), economic aspects (Black, 1984), and an underlying cultural tradition (Barnes, 1972; Flick, 1985). Also, it has been the subject of debate (Black, 1984; Holli, 1984) and an issue about which feeling sometimes runs very strong (Shell, 1988a and 1989). At APA's 1988 national meeting, a six-man industry panel concluded "the major barrier to forest worker professionalism is industry's fear of jeopardizing its independent contractor relationship with individual wood suppliers" (Griffin, 1988).

Results of three surveys indicated a modest degree of concern about the relationship between loggers and buyers. In

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[6] *These surveys were conducted in 1976, 1979, 1980, and 1987 (Watson et al., 1977; Weaver et al., 1981; Weaver et al., 1982; Watson et al., 1989).*

[7] *For an example of the use of a single survey in dispelling myths about the labor force, see Stevens' (1979) article appropriately titled, "Six Views About A Wood Products Labor Force, Most of Which May be Wrong."*

a 1985 opinion survey of pulpwood dealers and mill procurement managers, APA found "maintaining a union-free environment" and "arms length relationship" perceived as potential problems (APA, 1986b). However, the 35 respondents were much more concerned about cost and timber availability issues. The 1988 wants and needs survey gave respondents the opportunity to rank several subject areas that concern the pulpwood industry from time to time. Maintaining the independent status of loggers ranked next to bottom nationally; however, it ranked third in the APA Southwest Technical Division (Kansas, Oklahoma, Texas, Missouri, Arkansas, Louisiana, Mississippi, and Alabama), and pulp and paper company employees ranked it higher than logging contractors (APA, 1988). Finally, Wilson and Shaffer (1986) surveyed Virginia loggers ". . . to determine how they perceived their business relationship with the forest products companies they supply." The 111 loggers who responded felt that while the relationship was good, there was room for improvement. Perhaps more revealing was the perception by the loggers that the companies were unconcerned about the loggers' success and the finding that nearly one-fourth of the loggers would have liked to get out of the business altogether.

The contractual relationship between wood producers (loggers and dealers) and wood buyers/processors recently received a great deal of attention in a Southern trade publication. Shell (1989) described the relationship as follows:

> [M]ills dictat[e] when loggers can haul, where loggers can haul, how much they can haul per load, how loggers should harvest, where loggers can harvest, what woods workers can wear, how much insurance loggers must have, and how much they will be paid.

Mill procurement managers, on the other hand, complain that most of the loggers' problems could be solved if they were better business managers (Shell, 1989).

In their assessment of research needs, Silversides et al. (1988) identified the "impact of quotas" as a problem of medium priority under their "economics" problem area and recommended investigations of benefits, costs, and alternatives. Among those contacted during the course of this analysis, opinions about quotas depended upon one's perspective. Mill procurement managers generally viewed quotas as an essential control mechanism for regulating the flow of wood into the mill, although a few acknowledged that quotas prohibited some loggers from making a decent living. Loggers and wood dealers tended to express a more negative view of quotas as being unnecessarily restrictive. One former logger placed a great deal of blame upon the quota system for his getting out of the business.

Conclusion: The cogent question for purposes of this analysis is, what effect does the structure and organization of the harvesting industry have upon various aspects of harvesting operations, like productivity, worker turnover, accident rates, and skill levels of employees? In other words, does the control exerted by the wood buyers—in the form of quotas, prices, logging site selection, equipment use, etc.—contribute to many of the problems that exist in the harvesting industry? All dimensions of the wood procurement system should be systemically investigated: economic, legal-political, cultural, and social. Variations in logger-buyer relationships, such as the formation of logger associations,[8] should be studied for their impact upon the operational aspects of harvesting. While it is not the role of research to pass judgement upon matters like quota systems, arms length relationships, independence of loggers, or unionization, the effect of these phenomena upon other features or actions of the industry is a legitimate area of study.

Societal Influences: The Organizational Environment

An organization's (or industry's) environment includes "all phenomena that are external to and potentially or actually influence the population under study" (Hawley, 1968). Hall (1987) identified seven conditions within an organization's environment that should be analyzed: technological, legal, political, economic, demographic, ecological, and cultural. Examples of environmental influences upon the harvesting industry in each of these categories are readily available.

Technological Influences — The impact of the technological environment upon the logging industry over the past several years is common knowledge, and the trend toward more and more sophisticated equipment, although slowed, is continuing. The question of whether or not individual workers can keep pace with this sophistication already has been raised (Griffin, 1988), but technology impacts more than individuals who must operate new machines; it potentially affects the entire harvesting system. In describing new harvest equipment and systems at a recent technical conference, Sturos (1985) ended his presentation by stating, "The equipment alternatives presented in this paper should be evaluated in complete stump-to-mill system analyses. . . Only in this way can the merits of the equipment be realistically judged." Any such evaluations should include provision for assessing impacts upon the individuals, the crews, and the organizational system within which the technology is introduced.

Legal Influences — Like most other organizations, timber harvesting must live with federal, state, and local laws as constants in their environment, and there is concern within the industry about the restrictions imposed by law.[9] For example, deregulation of the railway industry resulted in increased

[8] *It was announced recently that pulpwood loggers in Mississippi will get a 15 percent reduction in workers' comp rates if they are fully mechanized; the Mississippi Loggers Association is given credit for proposing the rate adjustment to the state insurance commission (McPhail, 1989).*

[9] *Respondents to APA's wants and needs survey ranked "harvesting regulations" third among 10 areas of concern to the harvesting industry (APA, 1988).*

reliance upon trucks with an attendant increase in their numbers, capacity, length, and weight (Stephenson, 1988; Rolston, 1986). States reacted with a myriad of trucking regulations that left loggers in a state of confusion about what was legal and what was illegal (APA, 1981). Several industry representatives contacted during this analysis flatly stated that strict enforcement of weight and length restrictions would severely alter current trucking practices. The impact of these laws, and others currently or potentially affecting the harvesting industry, should be the subject of systematic analysis.

Political Influences — Laws often result from pressure for their enactment, and once legislation is passed, political pressures can be brought to bear in their implementation. McCaffrey (1982) has documented the strong political pressures that were placed upon the Occupational Safety and Health Administration (OSHA) during its early history. Sherar (1987) and Stuart (1988) have noted the importance of considering the political environment when making harvesting decisions. Sherar emphasized the potential for special interest groups to apply pressures that could affect logging (or already do); Stuart mentioned several areas where political pressures can complicate harvesting operations — land use debates, labor legislation, direct economic incentives, water and air quality standards, road construction and maintenance budgets, and public image (of harvesting). As Bond (1975) pointed out, "An understanding of the effect of public policy requires research rather than subjective speculation. . ."

Economic Influences — In most businesses, the state of the economy in which the organization is operating is the crucial variable. Loggers and wood products manufacturers suffered along with other sectors of American society during the general economic recession of 1980-81 (Knight, 1985). During the last few years, demand for paper has been very strong and pulp and paper companies have reported record profits.[10] Sherar and Sloan (1985) identified several economic conditions that may affect timber sales, and, consequently harvesting, in the eastern United States: timber stand quality/value, timber access costs, timber management costs, and higher valued uses of forest land, such as tourism and development. How the harvesting industry responds to these and other economic conditions is a legitimate research question.

Demographic Influences — Most businesses are concerned about the demographic composition of the buying public, and timber harvesters ultimately are affected by the characteristics of users of wood products. However, of greater interest to the harvesting industry is its *internal* demographic makeup. Research ". . .has shown that demographic distribution within an organization have important ramifications for a wide variety of organizationally important issues, such as performance, innovation and adaptability, turnover, and interorganizational linkages" (Hall, 1987). Some of the major research issues in this area — labor force characterization, availability, qualification, turnover — were discussed earlier in this paper. In sum, the demographic makeup of the logging industry should be examined closely as a possible contributor to some of the ills that plague the industry.

Ecological Influences — The physical environment affects the harvesting industry in two important ways. First, climatic and physiographic factors set limits on when, where, and how logging can occur. The industry has made significant progress in pushing back these limits through the development and use of new logging equipment and systems (Sherar, 1987). Second, and more troublesome, is concern about the physical environment by the American public. Environmental concern can manifest itself in the landowners who refuse to allow their timber to be cut (Broadway, 1989), motorists who successfully petition for a law prohibiting log trucks on the highway unless the mud is first removed (Rolston, 1986), or various special interest groups who want to prohibit harvesting in an area for as many different reasons as there are groups (Currie, 1989).[11] Sherar and Sloan (1985) identified visual quality, water quality, and wetlands as the major environmental concerns affecting harvesting in the East. Social scientists can play a role in helping the industry respond to these pressures.

Cultural Influences — At a 1988 conference on harvesting machines and systems evaluation Stuart (1988) reported results of an effort to find ways to alleviate the problems of translating harvesting research findings across regional and national boundaries. His general conclusion was ". . . that even among a selected set of highly developed countries producing similar products, the working and business environments differed greatly. These differences, not the mechanical, productivity or cost characteristics of the machine or a system were the final determinants of successful adaptation or evolution." Without using the term, Stuart presented a dramatic example of how culture impacts the harvesting industry's response to change in different countries or regions. In a sense, culture overrides all other factors in determining how an industry is shaped and operates (Hall, 1987). The cultural traditions underlying logging in the South have been noted already (Flick, 1985), and the gap between the sophistication of logging equipment and the sophistication of workers is a classic example of "cultural lag," a phenomenon described by a sociologist nearly 70 years ago (Ogburn, 1922). Other instances of cultural influences upon harvesting are regional differences in public perceptions of loggers, or the "image problem" (Kluender, 1976); the reluctance of workers to wear

[10] *This economic turnaround in the paper industry has contributed to the current hostility being expressed by some loggers toward the companies they log for. The loggers claim that they are not sharing in the economic bonanza (Shell, 1988a and 1989; Dunaway, 1989).*

[11] *In one of the most extreme proposals to date, the Wilderness Society has recommended that the allowable cut on national forests be reduced by one-half over the next 8 years (Anon. 1989).*

safety equipment;[12] and the lack of importance attached to formal training for loggers (Griffin, 1988). Social scientists should be involved in efforts to assess the impact of culture upon the harvesting industry and to try to forecast change which may influence the industry in the near future.

Conclusion: Many of the issues that face the southern harvesting industry emanate from one or more conditions within the social environment. While some industry observers, like Bond, Sherar, and Stuart, recognize the importance of societal influences, the capability to trace conditions in the industry to their sources and, thus, be in a better position to instigate change, has not been demonstrated. This capability is far from perfect in the social sciences, but there is a research tradition for the analysis of interorganizational and organization-environment interactions. The timber harvesting industry provides both a challenge and an opportunity for scientists interested in pursuing that tradition.

A Social Science Research Program

The third objective of this analysis of the southern timber harvesting industry was to identify specific specializations within the social science disciplines that should be applied to various harvesting problems. However, the discovery that social scientists of any persuasion have been inactive in timber harvesting research and the consequent paucity of social science based material in the knowledge base suggest that a proposed research program needs first to be pointed in a general direction else it goes flying off in several directions at once. Therefore, before a research program is proposed, a general orientation for social science study of timber harvesting will be briefly described.

Research Program Perspective

The theoretical perspective that has guided this analysis is that of the large-scale organization as an open social system. Although it is obvious that timber harvesting is not performed by a single, large-scale organization, the wood harvesting/transporting industry certainly meets the criteria of "a relatively permanent and relatively complex discernible interaction system" (Haas and Drabek, 1973). The alternative interaction systems — groups, communities, and societies — are either too transitory (groups) or too complex (communities, societies) to characterize the industry.

Perceiving timber harvesting as an organizational social system offers the advantage of familiarity to a wide array of social science disciplines. The pervasiveness of organizations in modern societies has attracted sociologists, psychologists, social psychologists, anthropologists, political scientists, and economists, and each discipline has made significant contributions to the "science of organizations" (Roberts et al., 1978). The interdisciplinary interest in organizations has resulted in research focused upon individual members, groups and individuals as group members, tasks performed, and the organization itself (Roberts et al., 1978). The potential relevance of each of these units of analysis for the study of timber harvesting has been specified or implied throughout this paper.

The open-system conceptualization of organizations seems most appropriate for guiding the analysis of the timber harvesting industry, primarily because of its emphasis upon a social system's interaction with other systems in its environment. That is, organizations are viewed as systems within systems. "The image is something akin to the layers one sees upon peeling an onion" (Haas and Drabek, 1973). The interdependency of the timber growing, harvesting, and wood processing social systems suggests that none can be analyzed in isolation from the others. The importance of the environment within which the timber harvesting industry exists has been stressed throughout this paper.

Research Program Description

Silversides and his colleagues (1988) recommended a 10-year program of research in timber harvesting and transportation with an estimated expenditure of 93 scientist years and $13,950,000. The "sociological aspects" of harvesting labor was allocated 3 scientist years and $450,000 of these totals. However, their "labor" problem area also included training programs, methods of payments, selection and retention of workers, and ergonomics, which have a combined total of 15 scientist years and $2,250,000 allocated. Furthermore, incentive programs, techniques of technology transfer, wood procurement strategies, and the impact of quotas are listed under different problem areas; all have been mentioned in this paper as needing attention by social scientists. Altogether, 25 scientist years and $3.3 million is the estimated requirement for a 10-year research program in these areas. Taking into account the need for involvement by physical and biological scientists in many of the areas, it is estimated that 10 social scientist years and $1.5 million would provide modest support for the research program proposed here. Allocation of these resources among the five problem areas and research subjects is shown in Table 1. Although the research subjects were deliberately left unranked in priority of initiation, the best opportunities for quick results probably are in the evaluation of selection, training, and motivation efforts, and labor force surveys. However, over the long run research in the structure and organization problem area would be expected to produce the most dramatic results in terms of bringing about needed changes in the industry.

[12] *In a survey of 509 loggers in 10 southern states, 60 percent reported wearing hard hats, 56 percent wore safety boots, 21 percent used eye protection, 26 percent hearing protection, and 19 percent leg protection, even though OSHA regulations have required 100 percent use of all this equipment except leg protectors for over 10 years (Griffin, 1988).*

Program Implementation

The greatest deterrent to the implementation and continuation of timber harvesting research in the United States has been recognized for at least a dozen years: there is no national focal point "for stimulating, sponsoring, and coordinating research to meet current and future needs in forest harvesting" such as exist in Sweden, Finland, Australia, New Zealand, and Canada (Boyd et al., 1977). The only national forestry research organization in this country is the USDA Forest Service, and the meagerness of that agency's timber harvesting research effort already has been noted (Silversides et al., 1988). The dispersed nature of research activities was vividly illustrated by the results of a 1984 survey of "all known public sector forest engineering research and development institutions in the United States and Canada" (Mann, 1984). In the United States, Mann identified 13 universities, six Forest Service research work units (in five experiment stations), and two other U.S. government research organizations, or a total of 21 semi-autonomous forest engineering research entities. In Canada, on the other hand, he identified only two universities and one government organization — the Forest Engineering Research Institute of Canada (FERIC).

Table 1. Recommended 10-year social science research program in timber harvesting

Problem area scientist and subjects	Estimated scientist year	Funding
INDIVIDUAL WORKERS		
— Evaluation of existing and new selection, training, and motivation efforts	2.0	$300,000
— Studies of other worker characteristics and issues	1.0	$150,000
	3.0	$450,000
HARVESTING CREWS		
— Case studies of crew organization & operations	2.0	$300,000
— Studies of effects of crew characteristics on selection, training & motivation	*	*
	2.0	$300,000
THE LABOR FORCE		
— Labor force characteristics surveys	0.5	$ 75,000
— Labor force issues studies	0.5	$ 75,000
	1.0	$150,000
STRUCTURE AND ORGANIZATION		
— Case studies of producer-buyer relationships	2.0	$300,000
— Evaluative case studies of logger cooperatives/associations	1.0	$150,000
	3.0	$450,000
SOCIETAL INFLUENCES		
— Macro analysis of impacts of environmental conditions	1.0	150,000
	1.0	$150,000
Recommended Program 10-Year Totals		
Individual Workers	3.0	$450,000
Harvesting Crews	2.0	$300,000
The Labor Force	1.0	$150,000
Structure & Organization	3.0	450,000
Societal Influences	1.0	$150,000
TOTAL	10.0	$1,500,000

*Included in evaluation studies under individual workers problem area.

The structural barriers to implementing and sustaining timber harvesting research could be partially overcome, in the case of social science research in the South, by placing a key scientist in a research and development position in a university or a government agency. The role for this person should include the following:

(1) Interpret social science research literature for application to timber harvesting and identify specific research needs.[13]
(2) Refer specific research needs to appropriate specialists in the social sciences.
(3) Obtain sponsorship for research from government sources, industry sources, foundations, and private donations.
(4) Serve as a consultant to the industry on matters pertaining to human behavior.
(5) Work with technology transfer agencies to assure that research results are disseminated.
(6) Serve as the social scientist on interdisciplinary research teams that normally are made up only of physical and/or biological scientists.

The individual occupying this position ideally would have academic training in some combination of psychology, sociology, social psychology, industrial psychology, industrial sociology, business administration, or management.[14] The resources allocated to the proposed 10-year research program will support this position, and the position will provide the opportunity for significant progress toward solving some of the problems that have plagued the timber harvesting industry for nearly 50 years.

[13]*Gary Latham, now chairman of the Department of Management and Organization, School of Business Administration, University of Washington, stated in a personal interview (1989) that there are several areas of knowledge in industrial psychology alone that have immediate application to harvesting problems; examples are goal setting as a means of increasing productivity (Locke and Latham, 1984), identification of supervisory potential and training for supervisors (Latham and Saari, 1979), the use of incentives (Yukl, Latham, and Pursell, 1976), and performance appraisal (Latham and Wexley, 1977). (Latham also helped develop the "Key Scientist" idea.)*

[14]*Latham related that it now is quite common for a Ph.D. industrial psychologist to have an MBA, for example.*

Literature Cited

Ager, Bengt (ed.). 1980a. Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980.

Ager, Bengt. 1980b. Design of work systems — a review. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 1-16.

Aherin, Robert A., and Dennis J. Murphy. 1987. Impact of operator training on reducing losses. Unpublished paper no. 87-5528 presented at the 1987 International Meeting of the American Society of Agricultural Engineers, Chicago, IL, Dec. 15-18, 1987.

Altman, James A. 1989. Personal communication.

American Pulpwood Association. 1981. Southern Guide to Federal and State Trucking Regulations. Special Project Report 81-A-5. American Pulpwood Association, Inc., Washington, DC.

American Pulpwood Association. 1985. Safe and Efficient Logging Crew Study. Publication 85-A-5, American Pulpwood Association, Inc., Northeastern Technical Division Safety Committee, Augusta, ME.

American Pulpwood Association. 1986a. Logging Industry Training Needs Survey Report. Publication 86-A-6, American Pulpwood Association, Inc., Northeastern Technical Division Training Sub-committee and VTI Craft Committee, Washington, DC.

American Pulpwood Association. 1986b. Opinions about Southern Pulpwood Procurement. Publication 86-A-2, American Pulpwood Association, Inc., Washington, DC.

American Pulpwood Association. 1987. Workers' Compensation Insurance Rates by States for Logging. Technical Release 87-R-24, American Pulpwood Association, Inc., Washington, DC.

American Pulpwood Association. 1988. The 1988 American Pulpwood Association Wants and Needs Survey: A Final Report. Publication 89-A-1, American Pulpwood Association, Inc., Washington, DC.

American Pulpwood Association. undated. Tailgate Logging Safety. Unnumbered Safety Booklet, American Pulpwood Association, Inc., Washington, DC.

Aminoff, Staffan, and Klas-Goran Lindstrom. 1980. On the decision process in the choice of highly mechanized logging systems. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 132-140.

Anonymous. 1989. Society wants harvesting cut in half. *Timber Harvesting* 37(4):5.

Bailey, Wilfred C., and Choong S. Kim. 1971. Community Factors in the Productivity of Pulpwood Harvesting Operations. University of Georgia, Department of Sociology and Anthropology, Athens, GA, in cooperation with the American Pulpwood Association Harvesting Research Project, Atlanta, GA.

Barnes, Peter. 1972. Pulpwood peonage: unionizing the rural South. *The New Republic*, March 18, 1972, 15-16.

Bendz, M. 1967. Community and service travelling of forest workers in Sweden. *Studia Forestalia Seucica* Nr. 38, Royal College of Forestry, Stockholm, Sweden.

Black, Richard L. 1984. Reasons for a large corporation moving toward or adopting an "armslength" independent contract for harvesting. *In* Robertson, Doris, and Julia White (ed.), People and Productivity: Keys to a Successful Harvesting Operation. Proceedings 7305 of a Conference sponsored by the Forest Products Research Society in cooperation with the Canadian Pulp and Paper Association, Thunder Bay, Ontario, Canada, Sept. 17-18, 1984, 34-36.

Blomquist, C.R. 1985. Silvicultural system alternatives: the forester's tool box. *In* Martin, A. Jeff (ed.), Timber Harvesting: the Link between Management and Utilization. SAF Publication 85-09, Proceedings of the Third Society of American Foresters Region V Technical Conference, Madison, WI, Sept. 25-27, 1985, 117-121.

Bond, Robert S. 1975. Labor research needs in the forestry economy of the United States. *In* Irland, Lloyd C. (ed.), Manpower — Forest Industry's Key Resource. Bulletin No. 86, Yale University School of Forestry and Environmental Studies, New Haven, CT, 178-183.

Bostrand, Lisbet. 1980a. Job satisfaction of logging machine operators in Sweden. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 17-25.

Bostrand, Lisbet. 1980b. Social effects of shift work in forestry. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 78-84.

Bostrand, Lisbet, and Bengt Fykman. 1975. Forest Work in the Nordic Countries from the Viewpoints of the Behavioral Sciences. Research Note Nr. 82, *Skogshogskolan*, Royal College of Forestry, Garpenberg, Sweden, 259-288.

Boyd, Coner W., Ward W. Carson, and Jens E. Jorgensen. 1977. Harvesting the forest resource — are we prepared? *Journal of Forestry* 75(7): 401-403.
Brinker, Richard. 1989. Personal communication.

Brinker, Richard. 1989. Personal communication.

Broadway, Regina. 1989. Timber harvesting practices studied. *MAFES Research Highlights* 52(1): 7-8.

Bryan, Richard W. 1981. How to find forest workers and keep them on the job. *Forest Industries* 108(9) 38-39.

Burton, Bruce. 1985. Improved operational and business management practices. *In* Martin, A. Jeff (ed.), Timber Harvesting: the Link between Management and Utilization. SAF Publication 85-90, Proceedings of the Third Society of American Foresters Region V Technical Conference, Madison, WI, Sept. 25-27, 1985, 122-127.

Cook, Karen S. 1977. Exchange and power in networks of inter-organizational relations. *The Sociological Quarterly* 18(1): 62-82.

Cooper, C., and I. Robertson (eds.). 1986. Review of Industrial and Organizational Psychology. Chichester, England: Wiley.

Cottell, Phillip L. 1975. Human factors in logging productivity. *In* Ireland, Lloyd C. (ed.), Manpower-Forest Industry's Key Resource. Bulletin No. 86, Yale University School of Forestry and Environmental Studies, New Haven, CT, 48-72.

Currie, Bob. 1989. Preservationists move South. *Timber Harvesting* 37(4): 37.

Deal, Earl. 1989. Personal communication.

Dunaway, H.L. 1989. Personal communication.

Duncan J.R. 1987. Human factors concepts: an overview. Unpublished paper No. 87-1595 presented at the 1987 International Meeting of the American Society of Agricultural Engineers, Chicago, IL, Dec. 15-18, 1987.

Dunn, J.G. 1972. Subjective and objective risk distribution: a comparison and its implications for accident prevention. *Occupational Psychology* 46: 183-187.

Flick, Warren A. 1985. The wood dealer system in Mississippi: an essay on regional economics and culture. *Journal of Forest History* 29(3): 131-138.

Frykman, Bengt. 1980. Studies on autonomy and work organization of logging crews in Sweden. *In* Ager, B. (ed.), Design of Work Systems in Forestry, Proceedings of an I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 53-77.

Garland, John J. 1979. A look at logger training. *Loggers Handbook* XXXIX: 14-17; 96, 98.

Garland, John J. 1982. Assessing gains from chokersetter training on skyline systems. *In* Burke, Doyle, Charles Mann, and Peter Schiess (eds.), Proceeding of the fifth Northwest Skyline Logging Symposium, University of Washington College of Forest Resources, Seattle, WA, Jan. 27 and 28, 1981, 97-105.

Garland, John J. 1984. Perspectives on the logging labor force: selection, training, and motivation. *In* Robertson, Doris, and Julia White (eds.), People and Productivity: Keys to a Successful Harvesting Operation. Proceedings 7305 of a Conference Sponsored by the Forest Products Research Society in cooperation with the Canadian Pulp and Paper Association, Thunder Bay, Ontario, Canada, Sept. 17-18, 1984, 7-29.

Garland, John J. 1986. Selection, training and motivation of the logging labor force. Unpublished paper presented at the 9th Annual Council of Forest Engineering meeting, Mobile, AL, Sept. 29 — Oct. 2, 1986.

Garland, John J. 1988. Perspectives on logging safety in Oregon. Unpublished background paper for a workshop on Strategies to Improve Logger Safety, Salem, OR, May 13-14, 1988.

Garland, John J. 1989. Personal communication.

Granskog, James E., and William C. Siegel. 1978. Legal distinctions between employee and independent contractor as applied to collective bargaining activities in timber harvesting. *Forest Products Industries* 28(9): 16-20.

Griffin, Griff. 1988. As machines get smarter, can workers keep pace? *Forest Industries* 115(7): 7,9.

Gustafsson, L., E. Layerlof, and B. Pettersson. 1971. An analysis of near accidents in cutting work. Report No. 4E, Logging Research Foundation, Stockholm, Sweden.

Haas, J. Eugene, and Thomas E. Drabek. 1973. Complex Organizations: A Sociological Perspective. New York: Macmillan.

Hall, Richard H. 1987. Organizations: Structures, Processes and Outcomes. Englewood Cliffs, NJ: Prentice-Hall.

Hamilton, Henry R. 1963. A Summary of the Southern Pulpwood Production Research Project to the American Pulpwood Association. Columbus, OH: Battelle Memorial Institute.

Hamilton, H.R., and J.R. Stock. 1962. Special Report on the Aggressiveness of Pulpwood Crews to the American Pulpwood Association. Columbus, OH: Battelle Memorial Institute.

Hansson, Jan-Erik. 1965. The relationship between individual characteristics of the worker and output of work in logging operations. *Steudia Forestalia Suecica* Nr. 29, Royal College of Forestry, Stockholm, Sweden.

Hawley, Amos H. 1968. Human ecology. *In* Sills, David L. (ed.), International Encyclopedia of the Social Sciences, New York: Macmillan. 4: 328-337.

Henderson, Mel. 1980. The future for research based work design in Australian logging. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 149-167.

Holli, David V. 1984. The independent contract experience from the logger's viewpoint. *In* Robertson, Doris, and Julia White (eds.), People and Productivity: Keys to a Successful Harvesting Operation. Proceedings 7305 of a Conference Sponsored by the Forest Products Research Society and the Canadian Pulp and Paper Association. Thunder Bay, Ontario, Canada, Sept. 17-18, 1984, 34-37.

Hull, R. Lewis, and Thomas A. Berry. 1987. Recommendations for an ASAE human factors safety design manual. Unpublished paper No. 87-1106 presented at the 1987 Summer Meeting of the American Society of Agricultural Engineers, Baltimore, MD, June 28-July 1, 1987.

Johansson, Gunn. 1980. Stress-strain at work: general knowledge and aspects. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 17-25.

Kinne, S.B., III. 1989. Personal communication.

Kjellstrand, Gunnar. 1980. Why did you quit? *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceeding of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 47-52.

Klen, T. 1977. Use of personal protectors and their influence on accidental head injuries of lumberjacks. Report No. TTI — 131, Institute of Occupational Health, Helsinki, Finland.

Kluender, Richard A. 1976. Improving the image of the pulpwood producer. Technical Paper 76-P-15, American Pulpwood Association, Washington, DC.

Knight, David. 1985. Wood tick trail. *Timber Harvesting* 33(12): 6-7.

Kyttala, Timo. 1978. Aspects of work organization in logging. *Folia Forestalia*, The Finnish Forest Research Institute, Helsinki, Finland.

Kytalla, Timo. 1980. Organizing logging work in Finland. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 85-89.

Landy, F. (ed.), 1986. Readings in Industrial-Organizational Psychology. Chicago: Dorsey Press.

Latham, Gary P. 1971a. Indicators of Productivity, Turnover, Absenteeism, and Injuries of Independent Pulpwood Producers: the Development of the APA-HRP Producer Behavior Inventory. American Pulpwood Association, Harvesting Research Project, Atlanta, GA.

Latham, Gary P. 1971b. The APA-HRP Producer Behavior Inventory (Pulpwood Dealers). American Pulpwood Association, Harvesting Research Project, Atlanta, GA.

Latham, Gary P. 1971c. The APA-HRP Producer Behavior Inventory (Company Foresters). American Pulpwood Association, Harvesting Research Project, Atlanta, GA.

Latham, Gary P. 1989. Personal communication.

Latham, Gary P., and Sydney B. Kinne, III. 1971. Goal Setting as a Means of Increasing the Performance of the Pulpwood Harvester. American Pulpwood Association, Harvesting Research Project, Atlanta, GA.

Latham, Gary P., and L.M. Saari. 1979. Application of social learning to training supervisors through behavior modeling. *Journal of Applied Psychology* 64: 239-246.

Latham, Gary P, and K.N. Wexley. 1977. Behavior observation scales for performance appraisal purposes. *Personnel Psychology* 30: 255-268.

Lindstrom, K.G., and C. Sundstrom-Frisk. 1975. Determining Factors in Incentive to Wear Personal Protective Equipment — Survey in the Logging Industry. Arbetarskyddsstryelsen, Stockholm, Sweden, Undersokningsrapport AMP 103(75).

Locke, E.A. (ed.). 1986. Generalizing from Laboratory to Field Settings: Research Findings from Industrial - Organizational Psychology, Organizational Behavior, and Human Resource Management. Lexington, MA: Heath Lexington.

Locke, Edwin A. and Gary P. Latham. 1984. Goal Setting: A Motivational Technique that Works! Englewood Cliffs, NJ: Prentice-Hall.

Makinen, Pekka. 1988. Forest machine operator as entrepreneur (English summary), *Folia Forestalia 717*, The Finnish Forest Research Institute, Helsinki, Finland.

Mann, John W. 1984. A summary of current forest engineering research and development in the United States and Canada. Unpublished paper presented at the joint meeting of the International Union of Forest Research Organizations (Division 3) and the Council on Forest Engineering, Orono, ME, Aug. 12-14, 1984.

Manz, John. 1988. Personal communication.

Mason, K. 1977. The effect of piecework on accident rates in the logging industry. *Journal of Occupational Accidents* 1: 281-294.

Mattson, James A. 1985. Harvest system alternatives: the logger's toolbox. *In* Martin, A. Jeff (ed.), Timber Harvesting: the Link between Management and Utilization. SAF Publication 85-09, Proceedings of the Third Society of American Foresters Region V Technical Conference, Madison, WI, Sept. 25-27, 1985, 122-127.

Mayo, S.C. 1962. A sociological approach to pulpwood procurement in the Appalachians. Technical Paper 62-P-73, American Pulpwood Association, Washington, DC.

McCaffrey, David P. 1982. OSHA and the Politics of Health Regulations. New York: Plenum.

McPhail, Carol B. 1989. Mechanized loggers get a break on workers' comp rates. *Clarion-Ledger, Jackson Daily News*, Jackson, MS, April 15, 1989, 4B.

Michie, Rob. 1983. An incentive for small tree harvesting. *In* Robertson, Doris (ed.), The Small Tree Resource: a Material Handling Challenge, Proceedings 7306 of a Conference sponsored by the Forest Products Research Society and the Canadian Pulp and Paper Association, Portland, OR, April 19-21, 1982, 91-94.

Ogburn, William F. 1922. Social Change with Respect to Culture and Original Nature. New York: Huebsch (Reprinted 1966, New York: Dell).

Olsen, Eldon D. 1988. Logging Incentive Systems. Research Bulletin 62, Oregon State University College of Forest Resources, Corvallis, OR.

Phillips, Rob. 1988. Death in the woods. *Sunday Oregonian Magazine*, Portland, OR, Nov. 13, 1988, 7-11.

Roberts, Karlene H., Charles L. Hulin, and Denise M. Rosseau. 1978. Developing an Interdisciplinary Science of Organizations. San Francisco: Jossey - Bass.

Robertson, Doris, and Julia White (eds.). 1984. People and Productivity: Keys to a Successful Harvesting Operation. Proceedings 7305 of a Conference Sponsored by the Forest Products Research Society and the Canadian Pulp and Paper Association, Thunder Bay, Ontario, Canada, Sept. 17-18, 1984

Roethlisberger, F.J., and W.J. Dickson. 1939. Management and the Worker. Cambridge, MA: Harvard University Press.

Rolston, Kenneth S. 1986. Log hauling in the South. *Forest Farmer* 45(9): 28-30.

Rolston, Kenneth S. 1988. Personal communication.

Rolston, Kenneth S. 1989. Personal communication.

Ronan, W.W., and G.P. Latham. 1969. The Job Performance of Pulpwood Producers. American Pulpwood Association, Harvesting Research Project, Atlanta, GA.

Ronan, W.W., and G.P. Latham. 1970. Effective producer performance. Technical Release 70-R-1, American Pulpwood Association, New York, NY.

Ronan, W.W., G.P. Latham, C.R. Tatro, and S. Aral. 1970. Community Variables Affecting the Pulpwood Harvesting Labor Force. American Pulpwood Association, Harvesting Research Project, Atlanta, GA.

Santopolo, F.A. 1962. Some insights to the problems of pulpwood procurement in the southern Appalachians. Technical Paper 62-P-72, American Pulpwood Association, New York, NY.

Sarna, R.P. 1977. A Quebec training improvement project: *The Psychological Profile of Forestry Workers* by Claude Forest and Rene Boulard. Technical Paper 77-P-25 (book review), American Pulpwood Association, Washington, DC.

Schaefer, Richard T. 1989. Sociology. New York: Macgraw-Hill.

Schuh, Donald D., and Loren D. Kellogg. 1988. Timber harvesting mechanization in the western United States: an industry survey. *Western Journal of Applied Forestry* 3(2); 33-36.

Shaffer, Robert M. 1989. Personal communication.

Shell, Dan. 1988a. Loggers deserve better. *Southern Loggin' Times* 17(10): 4.

Shell, Dan. 1988b. Open mouth, insert foot. *Southern Loggin' Times* 17(11): 5.

Shell, Dan. 1989. Exploring the procurement process. *Southern Loggin' Times* 18(1): 4.

Sherar, James R. 1987. Environmental influences affecting machine performance and selection in the southeastern United States. *In* Stuart, William B. (ed.), Proceedings of Harvesting Machines and Systems Evaluation Workshop, Charleston, SC, Nov. 18-19, 197-201.

Sherar, James R., and William H. Sloan. 1985. Meeting the Eastern challenge: planning and producing. Unpublished paper presented at the 8th Annual Council on Forest Engineering Meeting. Tahoe City, CA, Aug. 18-22, 1985.

Silversides, C. Ross, Donald M. Tufts, Thomas A. Walbridge, and Steven H. Bullard. 1988. Planning and Priorities for Timber Harvesting Research in the Southern United States. Bulletin 952, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Smith, Leo A., and Donald L. Sirois. 1982a. Ergonomic research: review and needs in southern forest harvesting. *Forest Products Journal* 32(4): 44-49.

Smith, Leo A., and Donald L. Sirois. 1982b. Review of human factors applications in forest harvesting. *In* Human Factors: A World of Human Potential, proceedings of the 26th Annual Meeting of the Human Factors Society, Santa Monica, CA, Oct. 25-29, 1982, 271-275.

Southern Industrial Forestry Research Council. 1986. Priority Research Needs from a Forest Industry View. Report No. 4, Southern Industrial Forestry Research Council/American Forest Council, Atlanta, GA.

Stephenson, E. 1988. Unpublished and untitled paper presented at a C and S Railroad—Union Camp Corporation meeting, Baltimore, MD, October 6-7, 1988.

Stevens, Joe B. 1979. Six views about a wood products labor force, most of which may be wrong. *Journal of Forestry* 77(11): 717-720.

Stevenson, John. 1988. Labor. *Timber Harvesting* 36(4): 18-20.

Stevenson, John. 1989. Start with safety: reducing workers' comp premiums. *Timber Harvesting* 37(3): 18-20.

Stuart, W.B. 1988. Harvesting machines and systems evaluation. *In* Stuart, William B. (ed.), Proceedings, Harvesting Machines and Systems Evaluation Workshop, Blacksburg, VA, June 21-22, 1988, 100-111.

Stuart, W.B. 1989. Personal communication.

Sturos, John A. 1985. New harvest equipment and systems. *In* Martin, A. Jeff (ed.), Timber Harvesting: the Link between Management and Utilization. SAF Publication 85-09, Proceedings of the Third Society of American Foresters Region V Technical Conference, Madison, WI, Sept. 25-27, 1985, 155-165.

Teikari, Eira. 1980. Methods for measuring job satisfaction. *In* Ager, B. (ed.), Design of Work Systems in Forestry. Proceedings of a I.U.F.R.O. Seminar, Garpenberg, Sweden, Sept. 21-26, 1980, 220-228.

Ubell, Earl. 1989. Is your job killing you? *Parade Magazine*, Jan. 8, 1989, 4.

U.S.D.A. Forest Service. 1988. The South's Fourth Forest: Alternatives for the Future. Forest Resource Report No. 24, USDA Forest Service, Washington, DC.

U.S.D.C. Bureau of the Census. 1989. County Business Patterns 1987, Washington, DC., U.S. Government Printing Office.

Walbridge, T.A. 1972. A Resume of the APA-HRP. American Pulpwood Association, Harvesting Research Project, Atlanta, GA.

Warren, B. Jack, and Julian A. Raburn. 1975. Effective Management of Pulpwood Logging Crews. Timber Harvesting Report No. 1, LSU/MSU Logging and Forestry Operations Center, MSU NSTL Research Center, Bay St. Louis, MS.

Watson, W.F., G.A. Day, Jim Altman, T.J. Straka, D.W. Domenech, and R.K. Matthes. 1989. 1987 Pulpwood Logging Contractor Survey. Technical Bulletin 162, Southwest and Southeast Technical Divisions of the American Pulpwood Association in cooperation with the Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Watson, W.F., J.M. Kucera, R.K. Matthes, and R.A. Kluender. 1977. Pulpwood Producer Census. Southwest and Southeast Technical Divisions of the American Pulpwood Association. Unnumbered Series, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Weaver, G.H., R.A. Kluender, W.F. Watson, W. Reynolds, and R.K. Matthes. 1981. 1979 Pulpwood Producer Census. Southwest and Southeast Technical Divisions of the American Pulpwood Association. Unnumbered Series, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Weaver, G.H., Bob Izlar, Richard Kluender, W.F. Watson and R.K. Matthes. 1982. 1980 Survey of High Volume Independent Wood Producers in the South. Unnumbered Series, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Wilson, Ed. 1988. Workers' compensation insurance studies. Unpublished presentation at 1988 Fall Meeting of the Southwestern Technical Division, American Pulpwood Association, Inc., Jackson, MS, Nov. 9-10, 1988.

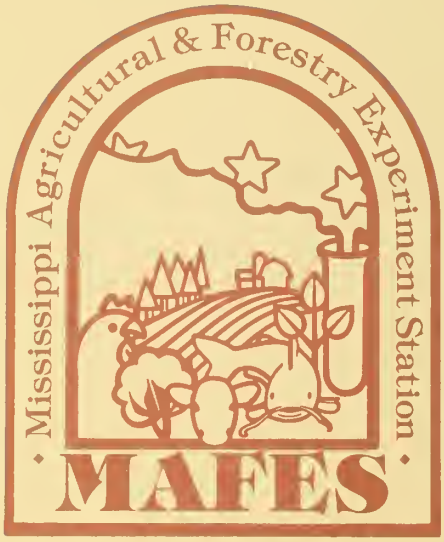
Wilson, Ed. 1989. Workers' comp: digging in the money pit. *Timber Harvesting* 37(2): 12-14.

Wilson, Peter, John Gaskin, and Barry Smith. 1988. Otago/Southland Logging Workforce Survey. LIRA Report Vol. 13 No. 17, New Zealand Logging Industry Research Association, Inc. Rotorua, New Zealand.

Wilson, Shawn, and Robert M. Shaffer. 1986. An opinion survey of Virginia loggers. Unpublished paper of Virginia Polytechnic Institute and State University, Department of Forestry, Blacksburg, VA.

Young, R.A. 1980. Sociology in Finnish forest research. *The Forestry Chronicle* 56(5): 209-212.

Yukl, G.A., G.P. Latham, and E.D. Pursell. 1976. The effectiveness of performance incentives under continuous and variable ratio schedules of reinforcement. *Personnel Psychology* 29: 221-231.



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Influence of Cultural Variables on Insect Populations in Soybeans

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Influence of Cultural Variables on Insect Populations in Soybeans

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Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine, Mississippi State University. Edited by Keith H. Remy, Publications Coordinator. Cover designed by Betty Mac Wilson, Artist.

Influence of Cultural Variables on Insect Populations in Soybeans

H. N. Pitre and R. P. Porter

Abstract

Cultural variables in agricultural production influence soybean insect populations and associated crop damage. Thus, the oldest of crop protection methods – cultural operations – should be considered in developing integrated insect pest management programs. These cultural operations impact on the biological and ecological relationships between insects and crop and noncrop vegetation. Particular emphasis in recent years has been given to more modern approaches to pest management utilizing cultural variables in crop production systems. These include date-of-planting, variety selection, row spacing, tillage, trap crops, doublecropping, and irrigation. The influences of these cultural variables can be observed by examining the impact of soil type and soil management, vegetational diversity, and insecticide interactions on pests and beneficial arthropods in various soybean cropping systems.

Introduction

Soybeans, *Glycine max* (L.) Merr., are grown alone or associated with cotton, corn, rice, peanuts, and/or grain sorghum in North America (Figure 1) and most of the Western Hemisphere. As soybean acreage increased in the Americas, so did the pest problems encountered with the extensive cultivation of this legume, believed to be native to eastern Asia (Hymowitz, 1970). There are at least 10 species of insects that may annually cause economic damage to soybeans in North America, but soybeans are usually a secondary host.

Some economic pests of soybeans in the Americas migrate from Central and South America into the continental United States. Species that commonly colonize other crops and/or noncrop vegetation build up on these hosts during early season and may damage soybeans during mid- to late-season. These pests move to soybeans when the primary host plants become unacceptable. The extent of these infestations and damage to the soybean crop are based on the number of insects moving from the primary host(s), the stage of development of the soybean crop when infested, and the duration of the infestation period.

The insect pests that coevolved with soybeans in the Orient, which are capable of fully exploiting soybeans as a food source, have not been introduced into the Western Hemisphere. Thus, the insect pests encountered on soybeans in the Americas have adapted to this crop. Because of the relatively short temporal association of these insects with soybeans, the pests

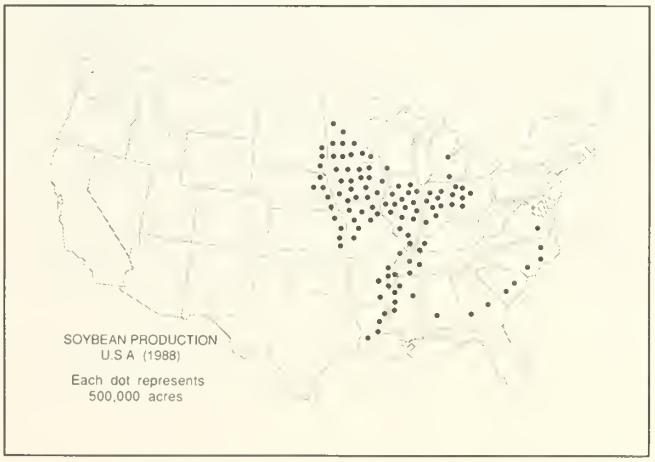

Figure 1. Major soybean producing areas in the United States. Map indicates 1988 production; each dot represents 500,000 acres.

and their natural enemies (beneficial arthropods) lack stability in their relationship with the soybean crop.

A wide range of insect pests attack and cause economic injury (Figure 2) and yield loss to soybeans in most areas with tropical and lower mid-latitude climate. The list of economic insect pests presented by Lambert (1988) includes species that feed on the roots, stems, stalks, foliage, and fruit. In some soybean-producing areas, crop damage is below economic levels because of several factors, including low populations of pest species, ability of the plants to compensate for insect damage, inadequacy of soybeans as host for the pest(s),and/or the crop escapes damage because the plant phenology is not synchronized with damaging levels of the pest population. When insect and plant phenological relationships are in synchrony, the pests may cause serious injury to the plants, resulting in economic crop yield loss.

Modifications to the crop production system may reduce colonization of the crop by insect pests and alleviate crop damage and losses caused by insect pest infestations. Injury to the plants may be avoided by producing the crop at times when pest populations are at low levels and/or in stages of development that do not damage the crop (Herzog and Funderburk, 1986). Modifications of crop production practices may alter the microclimate of the within-plant crop habitat, thus reducing establishment and injury levels of damaging pest insects. Alterations in cropping practices can have dramatic influences on pest biology and behavior. When these biological parameters are clearly defined, the relationships of insect pests with the soybean crop can be elucidated for use in developing and refining cultural control practices for specific insect pests or complexes of pests in soybeans.

Although chemical control methods are routinely employed to protect crops from insect pests, other approaches to insect pest control are available. Probably the oldest of these is cultural control. Cultural controls are the deliberate alterations of a production system (cultural practices) to reduce pest populations or avoid crop injury (Ashdown, 1977). Herzog and Funderburk (1985) described cultural controls as modifications of habitats that can create or destroy ecological niches for either pest or beneficial species. Thus, a single factor, or combination of factors can be used to regulate insect pests. Cultural control methods can be used to (1) impede insect colonization of a crop, (2) create adverse conditions that reduce the survival of the pest(s), and (3) modify the crop so damage by an infestation is minimal.

This bulletin considers some crop production practices that can influence infestations of insect pest and beneficial species in soybeans. Some attention is given to the direct and/or indirect influence of these cultural practices on biological parameters of particular insects. The apparent biological relationships responsible for the observed effects will be discussed, if known.

Crop Variety

The degree to which soybean production practices can be modified for insect control purposes is often dependent upon the crop variety selected for planting in specific agronomic situations. Therefore, variety selection is considered here to be a key to modifications that can be made in cultural practices.

Soybean types (varieties) selected for planting are usually chosen on the basis of yield and maturity date. When the crop is planted late or doublecropped behind another crop, late-maturing soybeans are selected for planting. Thus, earliness of plant maturity may not be a crop practice that can be utilized by some farmers for insect pest control. Soybeans that are planted late are often exposed to large late-season infestations of insect pests. A soybean type with short maturity is exposed less to most of the economic pests for a given geographic location than late-maturing soybeans (Litsinger and Moody, 1976).

Farmers may have the opportunity to select crop varieties with insect resistance characteristics, but unfortunately, soybean cultivars with resistance are not readily available for commercial use. Lambert (1988) considers this insect control approach in his review on host plant resistance to *Heliothis* spp. He mentions research indicating that some soybean accessions from maturity Groups VII and VIII of the World Collection showed high levels of resistance to foliage feeding by the corn earworm, *Heliothis zea* (Boddie); tobacco budworm, *H. virescens* (F.); soybean looper, *Pseudoplusia includens* (Walker); velvetbean caterpillar, *Anticarsia gemmatalis* (Hubner); and beet armyworm, *Spodoptera exigua* (Hubner). The choice of soybean variety can influence the development rate and relative fitness of a pest species (Beach and Todd, 1987). These effects may be attributed to larval antixenosis (nonpreference) or antibiosis (harmful effect on the insect resulting from larval feeding on the host plant). Oviposition may be reduced because of feeding on certain soybean varieties (Beach et al., 1985). The soybean variety influences the ability of the insect to damage the crop, time spent in a life cycle and ultimately the number of pest generations completed during the growing season.

Planting Date

Planting date may be dictated to some degree by weather, soil moisture, time constraints on the farmer, variety selection, and crop production system.

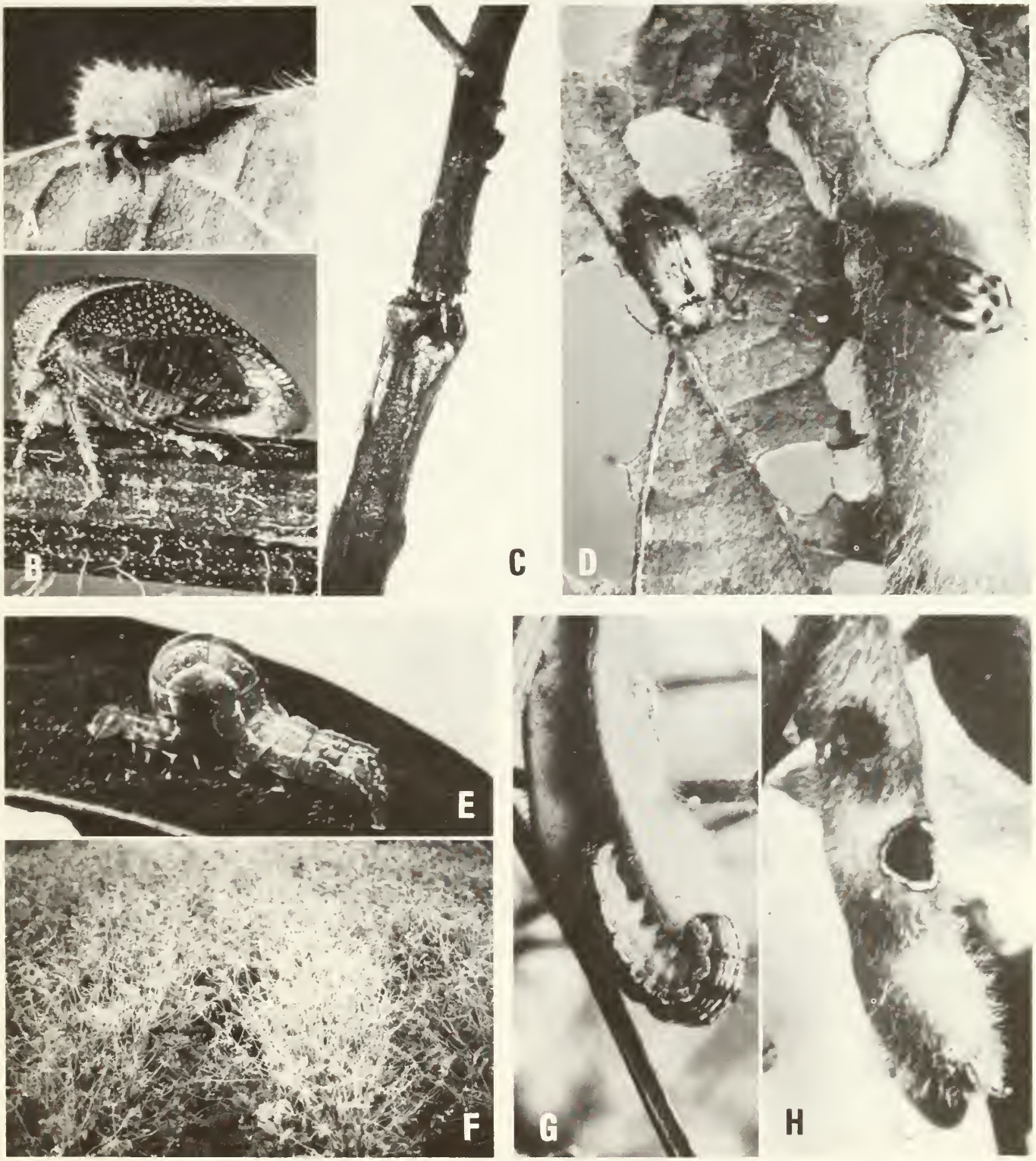

Figure 2. (A) Threecornered alfalfa hopper (TCAH) nymph; (B) TCAH Adult; (C) stalk girdled by TCAH. (D) Bean leaf beetle adults, two color types, and leaf and pod damage. (E) Soybean looper; (F) leaf feeding damage by soybean looper. (G) Corn earworm; (H) pod damage by corn earworm.

When soybeans are the main crop, planting of several varieties of different maturity dates is desirable to optimize harvest operation over time. The farmer must know which varieties produce highest yield on his farm and how they respond to insect attack. Early maturing soybean varieties may not have high yields and may not fit well into early planting schemes in many areas in the United States (Herzog and Funderburk, 1985), but this planting practice is becoming more popular with availability of new, high-yielding Group III and IV soybean types (Anonymous, 1989).

Defoliating caterpillars tend to be most abundant in late-planted, late maturing soybeans (Sloderbeck and Edwards, 1979; Boethel, 1984; Buschman et al., 1981). Preferred times for oviposition by pest insects on soybeans can be related to crop phenology and crop growth characteristics (Sloderbeck and Edwards, 1979; Boethel, 1984; Hillhouse and Pitre, 1976). For example, a soybean crop with open canopy (Figure 3a) in full bloom is more attractive and may experience heavy *Heliothis* infestations as compared to a crop with closed canopy (Figure 3b) and past the bloom stage. Crop phenology may also affect the relative fitness of insect pests in their ability to establish infestations on the plants (Terry et al., 1987). As plants mature past the pod-elongation stage, they may be less attractive to some lepidopterous defoliators, whereas stink bug infestations generally occur during this period. Predators don't appear to respond this strongly to crop maturity (Buschman et al., 1984).

Figure 3. Above: soybeans with open canopy (plants not overlapping row middles). Below: soybeans with closed canopy (plants overlapping row middles).

Plant Density (Row Width)

Row width in soybean production is less critical than with most crops because of the ability of plants to compensate for altered plant densities. When plants are water-stressed, plant density should not be high (not greater than 8 plants per foot of row on 40-inch rows), since high-density plantings use more water (Ferguson, 1988). With increased interest in soil conservation, and because the soybean crop may be planted late in soils with low moisture, there is a trend for narrow-row soybean production in some areas. This practice is often associated with no-till or reduced tillage cultivation, which will be discussed later in this bulletin. Soybeans in narrow rows (7-30 inches) with closed canopy are preferred by some insect species for oviposition and/or larval establishment (Mayse, 1978; Sprenkel et al., 1979; Buschman et al., 1981; Boethel, 1984; Troxclair and Boethel, 1984). Insect predators often show positive responses to the increased number of prey in the soybean crop, although they may not be influenced directly by row spacing or plant density (Dietz et al., 1976; Sprenkel et al., 1979).

Wide-row soybean plantings are easily sampled with a ground cloth (Figure 4a) or sweep net (Figure 4b), but narrow-row soybean plantings are difficult to sample. Because of the narrow rows, it is virtually impossible to use the conventional ground cloth procedure in sampling for arthropods. This is especially true for narrow-row soybeans planted with a grain drill. Therefore, the conventional sweep net has been the method of choice when sampling soybeans in narrow rows. The relative numbers obtained with a sweep net, although useful to crop consultants and researchers, need to be properly calibrated against reliable absolute sampling techniques for conversion to estimates of actual insect population density. Information is available for converting sweep net counts to absolute counts in wide- and narrow-row soybeans (Pitre et al.).

Insecticide efficacy is reduced in narrow-row soybean plantings compared to wide-row plantings, but the magnitude of the reduction is dependent upon the

Figure 4. Soybeans above are being sampled using a ground cloth while those below are being sampled using a sweep net (photo below is from slide provided by D. Boethel).

Figure 5. The soybeans above were planted using reduced tillage. The photo below shows soybeans, which were planted with no-tillage, after the harvest of wheat.

pest species and its behavior on the plant (Hutchins and Pitre 1984, 1987a, 1987b). The dense foliage in narrow-row soybean plantings hinders insecticide spray penetration into the canopy more than wide-row plantings, resulting in lower levels of insect pest control in the narrow-row plantings. Application efficiency may be increased when the insecticide is applied by ground rather than aerial equipment, particularly against hard-to-kill insect pests (Hutchins and Pitre, 1985).

Tillage

The most primitive insect control practices are mechanical, but to be of maximum benefit these practices need to be timed to susceptible stages in the life cycle of the insect pest(s) (Gebhardt, 1979). Tillage consists of operations to turn soil, bury residue, prepare the seedbed, and cultivate the crop. Most soybean pests and their natural enemies are affected by tillage to some extent (Herzog and Funderburk, 1985). Reduced or no-tillage (Figure 5) production practices reduce production costs and are being used in some areas where there is need for soil conservation, preservation of soil moisture, or where soybeans are planted late, often behind another crop. Soil planted to no-till may be cooler than similar conventionally-tilled soils, thus influencing aspects of pest biology and behavior. Noncrop vegetation in minimum tillage and no-tillage systems plays an important role in the dynamics of insect pest and natural enemy populations. Weeds and organic matter in or on the soil serve as protection, oviposition sites, and sources of food for insects (Hammond and Funderburk, 1985). These systems commonly support a higher species diversity and density of insects than conventionally-tilled systems.

Soil Insect Pests

No-till systems supported higher numbers of seed corn maggots, *Delia platura* (Meigen) (Hammond and Stinner, 1987a), and gray garden slugs, *Agriolimax reticulatus* (Muller) (Hammond, 1985; Hammond and Stinner, 1987b) than conventional tillage, whereas the soybean nodule fly, *Rivellia quadrifasciata* (Macquart), was not affected by tillage (Koethe et al., 1986).

Foliage Insect Pests

Plowing is suspected to increase mineralization and nitrogen availability (Stinner, 1981), thus the nitrogen content in plants in conventionally-tilled systems may be higher than in plants in reduced tillage systems. Plants in conventional tillage might be expected to experience greater herbivory than plants in no-till, since nitrogen appears to influence grazing rates in insects (Mattson, 1980).

Potato leafhoppers, *Empoasca fabae* (Harris) (Hammond and Stinner, 1987b), and green cloverworm, *Plathypena scabra* (Fabricius) (Sloderbeck and Yeargan, 1983), were not as abundant in no-till as in conventional tillage; whereas, grasshoppers (Figure 6) were more abundant in no-tillage fields. Funderburk et al. (1989) reported that pre-plant tillage had no gross effect on the population dynamics of the velvetbean caterpillar, green cloverworm, or southern green stink bug, *Nezara viridula* (Linnaeus) (Figure 6). Funderburk et al. (1989) indicated that reduced tillage is an acceptable way to optimize the presence of beneficial species in the field and increase the level of biological control.

Beneficial Insects

Predators, e.g. ground beetles (Figure 7) (House and Stinner, 1983), play an important role in the partial regulation of both grazing and detrital feeding insects. They are particularly influenced by soil tillage operations, whereas predators and parasites (Figure 8) on the foliage are affected little by these operations and play an important role in regulating foliar pests.

Non-Crop Vegetation

Tillage and previous cropping history influence the weediness of crop fields. These weeds modify the diversity and abundance of insect species infesting the crop. Foliage feeders, like velvetbean caterpillar, green cloverworm, and Mexican bean beetle, *Epilachna varivestis* (Mulsant), can be found in higher numbers in weed-free fields than in weedy fields (Altieri et al., 1981; Shelton and Edwards, 1983). High predator populations in weedy fields are responsible for reduced pest numbers in these fields. Although the advantages of weedy fields are apparent for control of certain insect pests, this management technique will not be easily accepted among agricultural scientists or producers (Herzog and Funderburk, 1985).

Crop System Diversity

Interest in alternative cropping practices is increasing. New crop production techniques may be discovered principally through novel disruption of the agroecosystem (Litsinger and Moody, 1976). Modifications of the cropping system by cropping system diversification might include rotation, planting a trap crop or crops, interplanting, doublecropping, strip cropping, and other variations in planting.

Rotation

Rotating crops usually has its greatest success against pests with long generation cycles and limited dispersal capabilities, e.g. the whitefringed beetle,

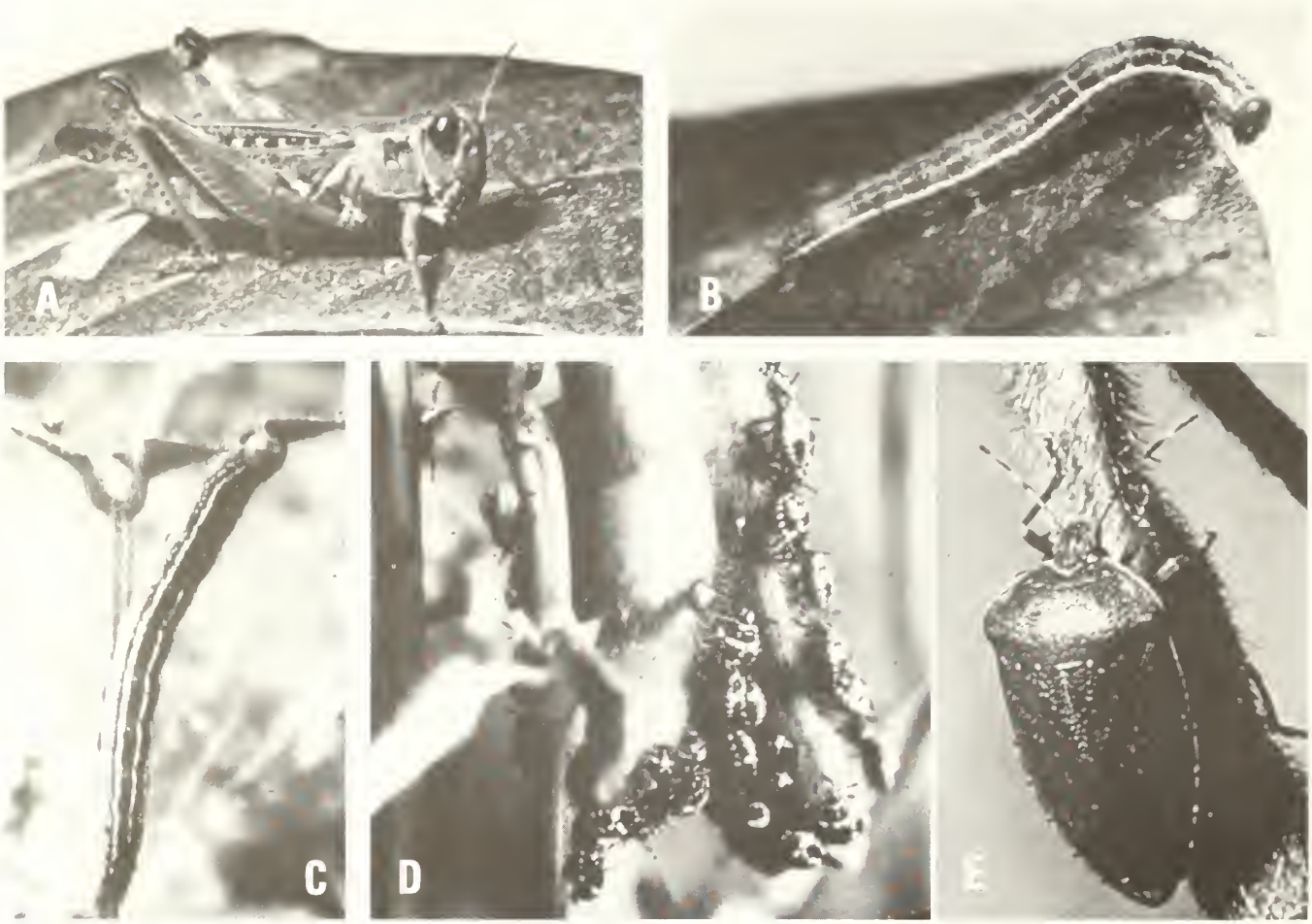

Figure 6. (A) Red-legged grasshopper; (B) green cloverworm; (C) velvetbean caterpillar; (D) southern green stinkbug nymphs and (E) adult.

Graphognathus sp. (Herzog and Funderburk, 1985). Whereas adjacent vegetation may be the key to establishing pest infestations on soybeans, e.g., soybean looper feeding on cotton nectar to enable heavy egg laying on soybeans (Burleigh, 1972; Jensen et al., 1974), crops (soybean or other crops) planted early (trap crop) and adjacent to the main planting can be important in reducing populations of pest species on the main soybean crop.

Trap Crop

The use of trap crop methods has proved beneficial against the bean leaf beetle (Newsom and Herzog, 1977) and stink bugs (McPherson and Newsom, 1984). Growers in an area must cooperate on planting date(s) in using trap crop methods for insect control. The trap crop is planted earlier (approximately 10% of planted acreage) and matures earlier than the main crop, thus attracting the insect pest(s) to the early-planted area where they may be controlled, if desired. However, the trap crop could serve as a nursery for pest insects if attention is not given to planting dates, pest buildup on the trap crop, and timing of control measures on the trap crop (if needed). The advantages of trap cropping include (1) economy, in that the area sprayed with insecticide is reduced; (2) minimum impact on beneficial insects; (3) minimum environmental pollution; and (4) delays development of insecticide resistance in the insects (McPherson and Newsom, 1984).

Interplanting

One disadvantage of monocultural practices is that pest species tend to build to economic levels because they have greater potential to expand under the conditions of reduced competition or interference. The literature shows that intercropping reduces pest infestations (Litsinger and Moody, 1976). The lower numbers of specific insects in interplanting systems may be attributable to chemicals released by nonhost plants of the pest, which adversely impact herbivorous pest species (Litsinger and Moody, 1976).

They also suggest that nonhost plants may chemically "mask" the presence of host species from potential attack. Additionally, plant mixtures in the field create more ecological niches for carnivore, as well as herbivore, populations.

Intercropping and stripcropping (crops planted in strips) may be responsible for increased beneficial insect populations and decreased pest populations, but as cultural practices for control of insect pests on soybeans, they have not gained as much attention by researchers as on other crops, e.g. corn-bean systems (Altieri, 1980). Herzog and Funderburk (1986) point out that intercropping strategies may be most practical when the main crop is an intensely-managed, high-value crop, and the interplanted crop is capable of withstanding large populations of pests with relatively minor economic loss. This may be an acceptable practice in the future, but today, intercropping is used most often in subsistence agricultural systems, generally in areas where soybeans are not produced in large commercial operations.

Figure 7. Ground beetle adult.

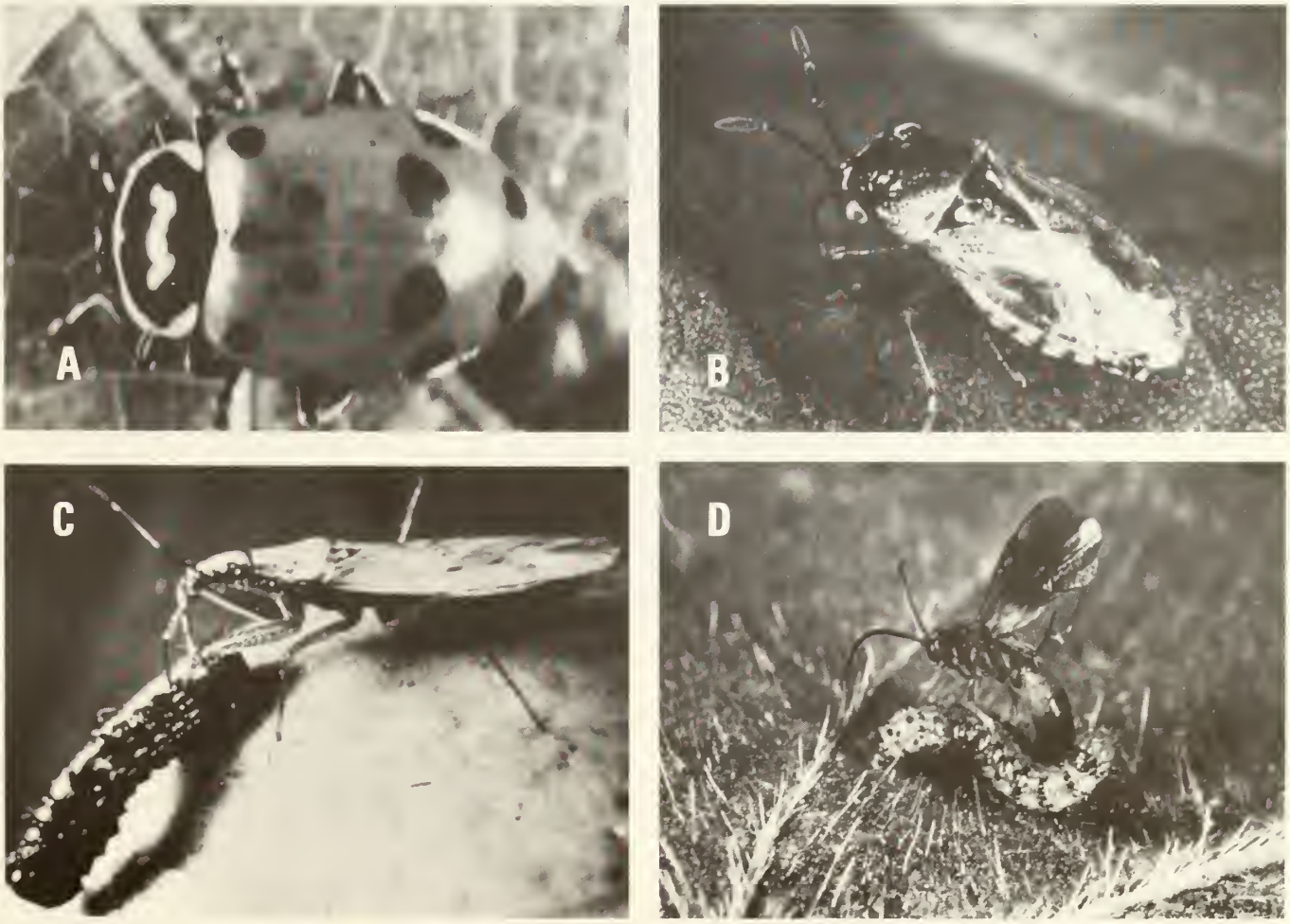

Figure 8. (A) Lady beetle; (B) big-eyed bug; (C) damsel bug; and (D) parasitic wasp.

Doublecropping

Doublecropping is an agricultural practice where two crops are produced on the same land during a 12-month period. This system of planting soybeans has received considerable interest by farmers in some areas during the past decade, particularly because of their critical cash flow situation. In the southern United States, for example, most doublecropped soybean acreage is planted immediately after spring harvest of wheat. Growing doublecropped soybeans increases producer risk of poor yield because of late planting dates, lack of soil moisture, weed problems, late-season insect problems, and the possibility of cold damage or inability to harvest the crop because of such late-season problems as the inability to drive equipment over wet soil. Management of many insect pest species that attack soybeans may be intensified by the cultural practices associated with effective doublecrop farming (Pedigo et al., 1981; Hammond and Jeffers, 1983). The influence of these cultural practices, including tillage, planting date, and row spacing in doublecropping systems on insect populations in soybeans was reviewed by Pitre (1985).

Irrigation

Irrigated soybeans (Figure 9) may have increased nutritional value and altered foliage canopy microclimate as compared with nonirrigated soybeans. These factors can contribute to insect pest infestations on soybeans. Early-season moisture stress reduces the number of branches and trifoliolates on the plants, thus providing an open leaf canopy, while irrigation assures a closed canopy. The closed canopy shades the lower leaves, lowers the canopy temperature, and maintains a higher relative humidity, resulting in a situation comparable to narrow-row soybeans.

In general, closed canopy soybeans have greater potential for damage by defoliating Lepidoptera, but also harbor higher numbers of beneficial insects (Micinski and Rabb, 1982; Boethel, 1984; Pitre, 1985).

Insect pests react differently to irrigation. Most pest and beneficial arthropods, with the exception of beet armyworms, soybean podworms, and bigeyed bugs, were more numerous in irrigated, closed-canopy soybeans than in nonirrigated, open-canopy soybeans (Felland, 1989). In some situations, the cooler and more humid microenvironment of closed-canopy soybeans allows early colonization by beneficial insects (Felland, 1989) and increased insect pathogen dispersal and infectivity (Thorvilson et al., 1985), which contribute to biological control of insect pests.

Summary

Methods of cultural control of insect pests are accomplished with modifications of crop production practices which may include tillage, planting date(s), row spacing, irrigation, and diversification of cropping systems. Selection of soybean varieties for planting using specific crop production practices under specific agronomic conditions is critical to modifications that may be made in crop management for insect pest control. Although variety selection is often based on yield and maturity date, farmers should plant soybean varieties with resistance to pests, when they are commercially available.

Implementation of successful cultural control practices utilizes information on insect seasonal occurrence, pest infestation levels required to cause economic crop losses, associations of pest and beneficial species with crop and noncrop vegetation, host plant resistance relationships, impact of host plants on insect population dynamics, and synchrony of occurrence of damaging stages of pests with critical plant growth stages. Insect pest and beneficial arthropod species react differently to densities of crop plants and noncrop vegetation, but in general narrow-row soybean plantings provide a favorable environment for pest and beneficial species usually encountered in soybeans. Irrigation, like narrow-row plantings, contributes to the early development of a closed canopy, which provides an attractive habitat for many insect species.

Insect populations often increase in early and mid-season to economic infestation levels in mid- to late-season, thus late-planted soybeans may be exposed to damage during critical stages of development (reproductive stages). Beneficial arthropods may be unable to regulate the explosive pest populations. Several insects damage soybeans during early plant development stages. Therefore, efforts should be made to plant the crop so that it escapes these early season infestations.

Tillage practices influence both the crop and arthropod pests in soybean fields. Noncrop vegetation competes with crop plants for space and soil nutrients, but provides diversity for establishment of a more stable agroecosystem. Insects are more damaging in weed-free fields than in weedy fields. This same effect can be observed in diversified cropping systems, including stripcropping, intercropping, and doublecropping, where the main soybean crop is damaged less than soybeans in monoculture.

Trap cropping practices are effective against some pests that are highly attractive to specific stages of the soybean plant at specific times during the growing season. Rotation of the crop away from the previous year's production site can be beneficial in

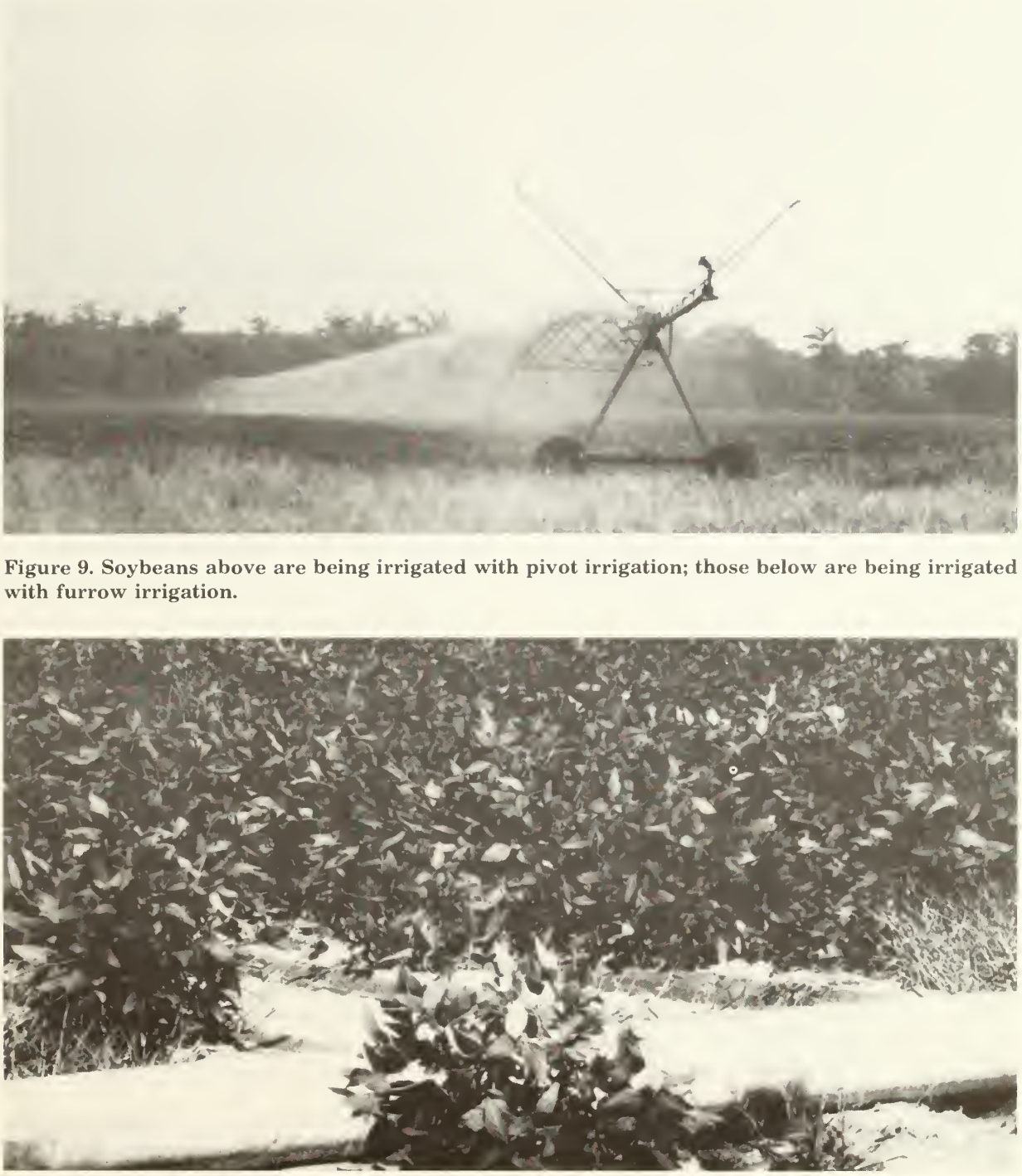

Figure 9. Soybeans above are being irrigated with pivot irrigation; those below are being irrigated with furrow irrigation.

reducing infestations of some pests.

Soybean cropping practices must consider the complex of pests, including insects, diseases, and weeds, attacking the crop at specific phenological stages, and times of occurrence of the pest(s) in developing a successful pest management program. Arthropod pest infestations may be limited by manipulation of cropping practices, but very often, particularly in monocultured systems, insecticides are required to prevent economic crop damage and yield losses. Ineffective insecticide control may be experienced if inadequate application techniques are employed in some soybean systems. Dense soybean foliage will hinder penetration of insecticides into the canopy, resulting in poor pest control, particularly the hard-to-kill species.

Modifications of cultural practices for cultural control of insects must consider aspects of the biology, ecology, behavior, and dynamics of both pest and beneficial species, and interactions with phenological stages of crop and noncrop vegetation to achieve highest levels of pest management possible, without major disruptions in the agroecosystem and the environment.

References

Altieri, M.A. 1980. Diversification of corn agroecosystems as a means of regulating fall armyworm populations. Florida Entomologist. 63:450-455.

Altieri, M.A., J.W. Todd., E.W. Hauser., M. Patterson., G.A. Buchanan, and R.H. Walker. 1981. Some effects of weed management and row spacing on insect abundance in soybean fields. Protection Ecology. 3:339-343.

Anonymous. 1989. Exploring soybean earliness. Ag Consultant. 45(2):12-13.

Ashdown, D. 1977. Life of Insects. Texas Tech University, Lubbock, TX, 135 pp.

Beach, R.M., and J.W. Todd. 1987. Resistance of the soybean breeding line GATIR 81-296 to foliar feeding by three *Spodoptera* sp. Journal of Agricultural Entomology 4(3):193-199.

Beach, R.M., J.W. Todd, and S.H. Baker. 1985. Antibiosis of four insect- resistant soybean genotypes to the soybean looper (Lepidoptera: Noctuidae). Environmental Entomology. 14:531-534.

Boethel, D.J. 1984. Evolving crop production systems for soybean: impact on pest and beneficial arthropod species. *In* Wong, S., Boethel, D.J., Nelson, R., Nelson, W., and Wolf, W. (Eds) Proceedings United States-China Soybean Symposium II. USDA-OICD, Washington, DC, 464 pp.

Burleigh, J.G. 1972. Population dynamics and biotic controls of the soybean looper in Louisiana. Environmental Entomology. 1:290-294.

Buschman, L.L., H.N. Pitre, and H.F. Hodges. 1981. Soybean cultural practices: effects on populations of green cloverworm, velvetbean caterpillar, loopers, and *Heliothis* complex. Environmental Entomology. 10:631-641.

Buschman, L.L., H.N. Pitre, and H.F. Hodges. 1984. Soybean cultural practices: effects on populations of geocorids, nabids, and other soybean arthropods. Environmental Entomology. 13:305-317.

Dietz, L.L., J.W. Van Duyn, J.W. Bradley, Jr., R.L. Rabb, W.M. Brooks, and R.E. Stinner. 1976. A guide to the identification and biology of soybean arthropods in North Carolina. North Carolina Agricultural Experiment Station Tech. Bull. No. 238.

Felland, C.M. 1989. Ecology of pest and beneficial arthropods in irrigated and dryland soybean. Ph.D. Dissertation, Mississippi State University, Mississippi State, MS, 77 pp.

Ferguson, J. 1988. Drought strategies. Ag Consultant. 44(8):1-3.

Funderburk, J.E., D.L. Wright, and I.D. Teare. 1989. Preplant tillage effects on population dynamics of soybean pests. Crop Science. (In Press).

Gebhardt, M.R. 1979. Engineering aspects of pest control. *In* Ennis, W.B. Jr., (Ed.) Introduction to Crop Protection. American Society of Agronomy, Madison, WI, 524 pp.

Hammond, R.B. 1985. Slugs as a new pest of soybeans. Journal of the Kansas Entomological Society. 58:364-366.

Hammond, R.B., and J.E. Funderburk. 1985. Influence of tillage practices on soil-insect population dynamics. *In* Shibles, R., (Ed.) Proceedings of the World Soybean Conference III. Westview Press, Boulder, CO, pp. 659-666.

Hammond, R.B., and D.L. Jeffers. 1983. Adult seedcorn maggots in soybeans relay intercropped into winter wheat. Environmental Entomology 12:1487-1489.

Hammond, R.B., and B.R. Stinner. 1987a. Seedcorn maggots (Diptera: Anthomyiidae) and slugs in conservation tillage systems. Ohio Journal of Economic Entomology. 80:680-684.

Hammond, R.B., and B.R. Stinner. 1987b. Soybean foliage insects in conservation tillage systems: effects of tillage, previous cropping history, and soil insecticide application. Environmental Entomology. 16:524-531.

Herzog, D.C., and J.E. Funderburk. 1985. Plant resistance and cultural practice interactions with biological control. *In* Hoy, M.A. and Herzog, D.A (Eds.) Biological Control in Agricultural Integrated Pest Management Systems, Academic Press, New York, pp. 67-88.

Herzog, D.C., and J.E. Funderburk. 1986. Ecological bases for habitat management and pest cultural control. *In* Kogan, M., (Ed.) Ecological Theory and Integrated Pest Management Practice. John Wiley and Sons, New York. pp. 217-250.

Hillhouse, T.L, and H.N. Pitre. 1976. Oviposition by *Heliothis* on soybeans and cotton. Journal of Economic Entomology. 69:144-146.

House, G.J., and B.R. Stinner. 1983. Arthropods in no-tillage soybean agroecosystems: community composition and ecosystem interactions. Environmental Management. 7:23-28.

Hutchins, S.H. and H.N. Pitre. 1984. Effects of soybean row spacing on spray penetration and efficacy of insecticides applied with aerial and ground equipment. Environmental Entomology. 13: 948-953.

Hutchins, S.H., and H.N Pitre. 1985. Differences in penetration and efficacy of insecticide sprays applied by aerial and ground equipment to soybean. Journal of Entomological Science. 20:34-41.

Hutchins, S.H., and H.N Pitre. 1987a. Differential mortality response of lepidopteran defoliators to insecticides deposited within three strata of wide- and narrow-row soybeans. Journal of Economic Entomology. 80:1244-1248.

Hutchins, S.H., and H.N. Pitre. 1987b. Soybean row spacing: effects on insecticide efficacy against three common lepidopteran defoliators of different size classes. Journal of Economic Entomology. 80:169-174.

Hymowitz, T. 1970. On the domestication of the soybean. Economic Botany. 24:408-421.

Jensen, R.L., L.D. Newsom, J. Gibbens. 1974. The soybean looper: Effects of adult nutrition on oviposition, mating frequency, and longevity. Journal of Economic Entomology. 67:467-470.

Koethe, R.W., F. Gould, and J.W. Van Duyn. 1986. Soybean nodule fly, *Rivellia quadrifasciata* (Diptera: Platystomatidae): aspects of overwintering and adult seasonal abundance. Environmental Entomology. 15:349-354.

Lambert, L. 1988. Host plant resistance in soybean to *Heliothis* species. *In* Herzog, G.A., Ramaswamy, S., Lentz, G., Goodenough, J.L., and Hamm, J.J., (Eds.) Theory and Tactics of *Heliothis* Population Management: III–Emerging Control Tactics and Techniques. Southern Cooperative Series Bulletin 337. pp.13-20.

Litsinger, J.A., and K. Moody. 1976. Integrated Pest Management in Multiple Cropping Systems. *In* Kral, D.M., Eisele, L.C., Nauseef, J.H., (Eds.) Multiple Cropping. American Society of Agronomy Special Publication Number 27. American Society of Agronomy, Madison, WI, pp. 293-316.

Mattson, W.J. 1980. Herbivory in relation to plant nitrogen content. Annual Review of Ecology and Systematics. 11:119-161.

Mayse, M.A. 1978. Effects of spacing between rows on soybean arthropod populations. Journal of Applied Ecology. 15:439-450.

McPherson, R.M., and L.D. Newsom. 1984. Trap crops for control of stink bugs in soybean. Journal of the Georgia Entomological Society. 19(4):470-480.

Micinski, S., and J.L. Rabb. 1982. Evaluation of soybean insect defoliation as influenced by management practices. Red River Valley Agricultural Experiment Station Annual Report, Louisiana Agricultural Experiment Station, Bossier City, LA, pp. 283-284.

Newsom, L.D., and D.C. Herzog. 1977. Trap crops for control of soybean pests. Louisiana Agriculture. 20:14-15.

Pedigo, L.P., R.A. Higgins, R.B. Hammond, and E.J. Bechinski. 1981. CRC Handbook of Pest Management. Pimentel, D. (Ed.) Volume 3. CRC Press, Boca Raton, FL.

Pitre, H.N. 1985. Ecological effects of double cropping on soybean insect populations. *In* Shibles, R. (Ed.) World Soybean Research Conference III. Proceedings. Westview Press, Boulder, CO.

Pitre, Henry N., Larry G. Thead, and Jim L. Hamer, 1987. Prediction of field populations of soybean insects from sweep-net samples in narrow-row soybean plantings. J. Econ. Entomol. 80:848-853.

Shelton, M.D., and C.R. Edwards. 1983. Effects of weeds on the diversity and abundance of insects in soybeans. Environmental Entomology. 12:296-298.

Sloderbeck, P.E., and C.R. Edwards. 1979. Effects of soybean cropping practices on Mexican bean beetle and redlegged grasshopper populations. Journal of Economic Entomology. 72:850-853.

Sloderbeck, P.E., and K.V. Yeargan. 1983. Green cloverworm (Lepidoptera: Noctuidae) populations in conventional and doublecrop, no-till soybeans. Journal of Economic Entomology. 76:785-791.

Sprenkel, R.K., W.M. Brooks., J.W. Van Duyn, and L.L. Deitz. 1979. The effects of three cultural variables on the incidence of *Nomuraea rileyi*, phytophagous Lepidoptera and their predators on soybeans. Environmental Entomology. 8:334-339.

Stinner, B.R. 1981. Nutrient budgets and internal cycling of N, P, K. Ca, and Mg in conventional, no-tillage and old field systems on the Georgia Piedmont. Ph.D. dissertation, University of Georgia, Athens, GA, 86 pp.

Terry, I., J.R. Bradley, Jr., and J.W. Van Duyn. 1987. Survival and development of *Heliothis zea* (Lepidoptera: Noctuidae) larvae on selected soybean growth stages. Environmental Entomology. 16:441-445.

Thorvilson, H.G., L.P. Pedigo, and L.C. Lewis. 1985. *Plathypena scabra* (F.) (Lepidoptera: Noctuidae) populations and the incidence of natural enemies in four soybean tillage systems. Journal of Economic Entomology. 78:213-218.

Troxclair, N.N., Jr., and D.J. Boethel. 1984. Influence of tillage practices and row spacing on soybean insect populations in Louisiana. Journal of Economic Entomology. 77:1571-1579.

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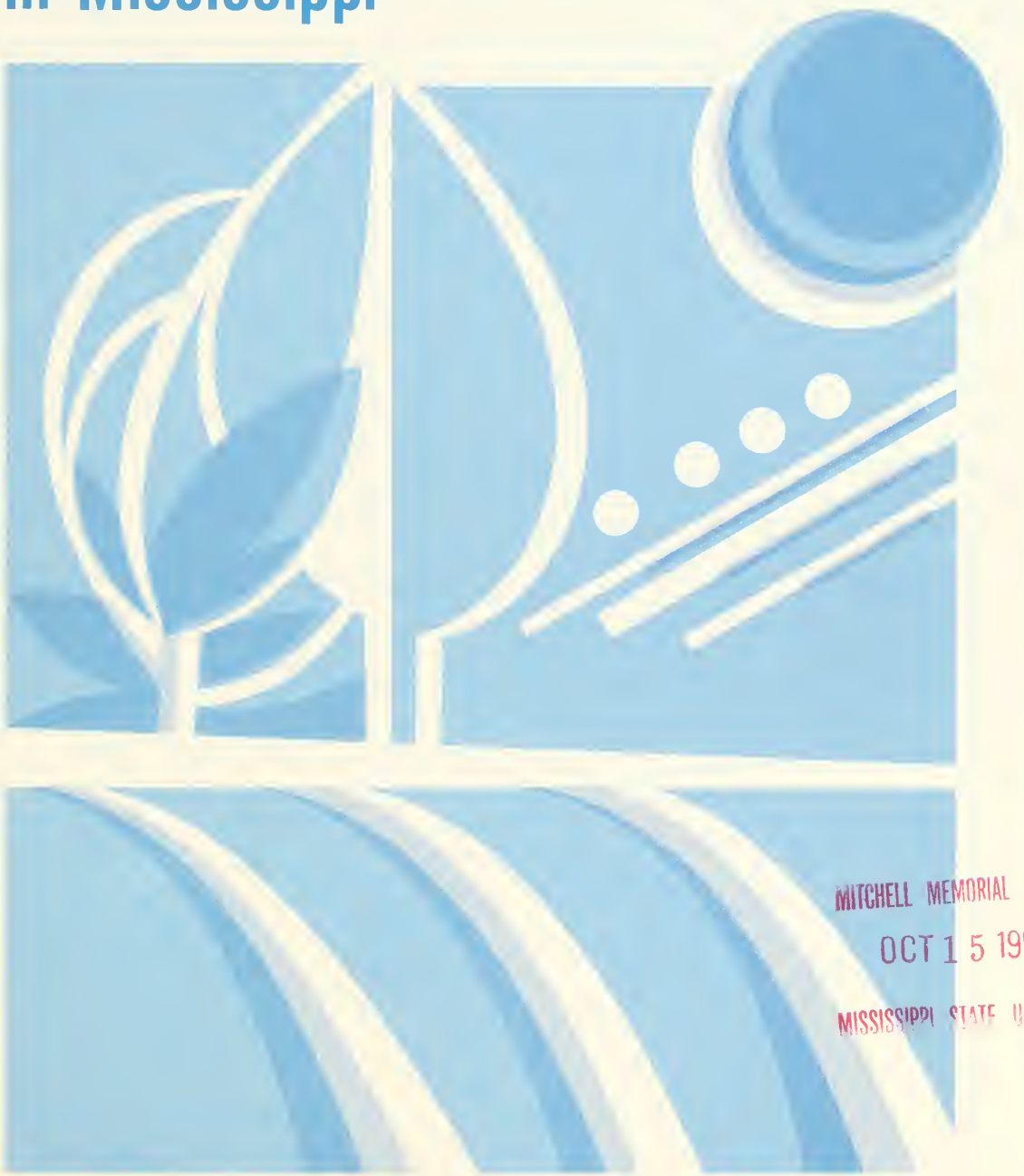

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Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine. Edited by Keith H. Remy, Publications Coordinator. Cover designed by Mary Frances Dillard, Artist.

Preface

Weather and climate influence virtually all phases of production in agriculture and forestry. The climatic data, either basic or derived, needed for decision-making by Mississippi producers are not generally available except in diverse forms and sources. This document compiles into one comprehensive source many of those needed data. Data are presented in tabular and graphical formats covering several aspects of each of the broad areas of moisture, energy, and derived variables. Specific topics for which data are presented include precipitation, temperature, freeze dates, solar radiation, day length, evaporation, DD60's, water temperature, water balance, and crop water demand. Unavailability of wind and relative humidity data, as well as data for short time periods, such as hourly, is discussed.

Acknowledgments

The authors wish to acknowledge the contributions of the following to the preparation of this document:

The Mississippi Agricultural and Forestry Experiment Station and the Departments of Agricultural and Biological Engineering and Geology and Geography, Mississippi State University, for financial support of the State Climatologist program and for funding this project.

Dr. Mark S. Binkley, Director, Climatology Laboratory, Department of Geology and Geography, Mississippi State University; Dr. Thomas A. Monaghan, Extension Leader for Forestry, Mississippi Cooperative Extension Service; and Dr. George P. Mullendore, Coordinator, USDA Cotton Simulation Program, for critical review of the manuscript.

B.J. Whitehead and Pam Shaunak for their courteous help in graphics and typing of the manuscript.

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Selected Climatological Features Affecting Agriculture and Forestry in Mississippi

Introduction

The suitability of a region for agricultural and forestry production is strongly influenced by the climatic attributes of the region. Growth of plants in any environment is dependent upon the delivery, by climatic processes, of moisture and energy to the land surface. Virtually all phases of plant and animal life – germination, growth and developement, maturity, yield or productivity, reproduction – are influenced to some degree by the environmental factors of weather and climate. Furthermore, both agricultural and silvicultural crops are subject to a wide variety of diseases and insects that are weather and climate dependent. Principal features of climate that establish limits for growth and development of crops and forests are characteristics of moisture, energy, and quantities derived from the interplay of these factors.

Many of the basic and most of the derived climatological variables needed to understand the impact of climate on plant or animal production are not generally available, or are not available in the form required, for Mississippi producers. Mississippi Agricultural and Forestry Experiment Station scientists, the State Climatologist, and Mississippi Cooperative Extension Service specialists often receive requests for such weather and climate information. The purpose of this document is to present selected aspects of climatological data that are available by consolidating a variety of information from a number of different sources. Some of the information is in the form of raw data, some is in the form of derived variables that have been computed, and some is in a form not usually published but for which a demand exists.

Data Sources, Adjustments, and Presentation

Topics selected for presentation fall into one of three categories: (1) moisture–precipitation; (2) energy–temperature, solar radiation, daylength, and evaporation; and (3) derived variables–degree day 60 heat units (DD60's), water temperatures, water balance, and crop water demand. The order of the topics generally follows a progression from those data most available to those data least available.

Some of the features portrayed are simple and required only that the data be assembled. Others are complex and required multiple procedures to process and make the data available. A variety of tables and figures are used, and several methods were used to correct for missing data or otherwise adjust records to ensure the best possible quality and serial consistency of the data. Details of the methods used to retrieve, correct or adjust, and analyze the data within each topic are included with the data for each topic.

Precipitation

Precipitation data presented are monthly totals observed in each of the 10 climate divisions for the 30-year period 1960-1989. The data are presented in tables and in isohyet maps.

Tables 1-10 include monthly total precipitation from representative climate recording stations within each of the 10 climate divisions in the state. Data were retrieved from CD-ROM based on National Weather Service Cooperative Observation Network records available through Earth Info, Inc. (Climatedata, 1989). Stations were chosen based upon the quality and completeness of the records. Missing data were inserted into the records by using either the divisional average or the measurement from the nearest station for the month in question. Therefore, the data are serially complete and quality controlled and are available in no other published source.

Each table includes monthly and annual totals of precipitation (inches) for each year, average monthly and annual totals of the 30-year period, as well as monthly and annual maximum and minimum amounts recorded. Monthly standard deviations are also included. For example, Table 1 (Climate Division 1, represented by Cleveland, MS) shows that there was a total of 5.83 inches in January 1960, the average monthly amount for 1960 was 4.38 inches, and the maximum and minimum monthly amounts observed in 1960 were 6.47 inches (Dec.) and 2.37 inches (Aug.), respectively. The average for January is 4.42 inches, the maximum for January is 11.54 inches (1974), the minimum for January is 0.38 inch (1986), and the standard deviation for January is 2.72 inches.

These same data are presented in a visual format by mapping the distribution of precipitation across the state for each month and annually (Figures 1-13). This information is a unique addition to the Mississippi climatological literature because, in addition to the

10 locations inside the state, data from 11 locations outside but near the state boundaries were similarly retrieved and processed for use in the mapping procedure. This addition of data points outside the state increases the accuracy of the spatial depiction of monthly precipitation by carrying the analysis across the borders and thereby negating the artificial constraints usually associated with such mapping attempts.

Temperature

Daily maximum and minimum temperature data for the period 1951-1980 were retrieved from CD-ROM based on National Weather Service Cooperative Observation Network records available through Earth Info, Inc. (Climatedata, 1989). Stations were chosen from the northern (Water Valley), central (Canton), and southern (Hattiesburg) parts of the state based upon the quality and completeness of the records. Missing data were inserted into the records by using the measurement from the nearest station for the day in question. Therefore, the data are serially complete and quality controlled, and are available in no other published source.

The adjusted daily data were retrieved into Lotus 1-2-3 spreadsheets (Lotus, 1986) and an average value was calculated for each day. These average daily values, maximum and minimum, were graphed to show the annual regimes of temperature at the three locations and to show the spatial differences in temperature across the state through the year (Figures 14, 15, and 16).

Also included (Table 11), are probabilities of the first and last freeze dates and length of the freeze-free period for the same three locations. These data were derived and published for these locations and others in the state by the National Climatic Data Center (1985), and are included here to enhance the understanding of the temperature regime as it impacts agriculture and forestry in the state.

Solar Radiation

The solar radiation data were observed at Delta Branch Experiment Station, Stoneville, MS, and stored in computer files at Mississippi State University. The data were retrieved and formatted into Tables 12-23 to provide daily values by month for the years 1962-1987. The observed values, computed average, maximum value, and minimum value for each day as well as the monthly totals are given in units of calories/square centimeter/day. For example, Table 12 shows that the observed value for January 10, 1970 is 196 cal/sq cm, the 26-year average for January 10 is 210 cal/sq cm, the maximum observed for that date is 545 cal/sq cm (1962), and the minimum observed for that date is 42 cal/sq cm (1974). The monthly total for January 1970 is 8035 cal/sq cm.

Day Length

The length of daylight in Mississippi is presented in Tables 24-26, as computed from equations found in Duffie and Beckman (1980). Locations in the northern (Water Valley), central (Canton), and southern (Hattiesburg) parts of the state are used to illustrate the varying periods of light (hours) across the state during the year. For example, on January 1, daylength ranges from 9.8 hours in the north (Table 24) to 10.0 hours in the southern (Table 26) part of the state, whereas on June 30, the length of daylight ranges from 14.0 hours in the south (Table 26) to 14.3 hours in the northern (Table 24) part of the state.

Evaporation

Evaporation data were retrieved from CD-ROM, available from the National Weather Service Cooperative Observation System through Earth Info, Inc. (Climatedata, 1989). The data were retrieved into Lotus 1-2-3 spreadsheets (Lotus, 1986) for inspection and quality control. The raw data were serially incomplete and contained obvious errors.

In order to produce a serially complete and more accurate daily evaporation record, the raw data were used to compute an average for each day of the year. The average was then used to fill in missing daily values for every year. These daily values for each year were then graphed on the computer monitor and visually inspected for abnormally high and low points, which were noted and subsequently located in the data files. Adjustments were then made to correct for the identified errors such as accumulated values following a long string of missing observations or typographical mistakes. If the observation in question appeared obviously wrong but no cause was readily evident, the average value for that day was substituted. Less than 4 percent of the observations were adjusted in this manner. The result of this tedious procedure yields a reasonably accurate and complete record of daily pan evaporation.

The adjusted data for Stoneville, MS, were formatted into Tables 27-38 to provide daily values by month for the years 1962-1987. The observed values, computed average, maximum value, and minimum value for each day as well as the monthly totals are given in units of inches/day. For example, Table 27 shows that the observed value for January 10, 1970 is 0.02 inch, the 26-year average for January 10 is 0.03 inch, the maximum observed for that date is 0.13 inch (1984), and the minimum observed for that date is 0.0

inches (observed in 5 years). The monthly total for January 1970 is 0.54 inch.

In order to depict the envaporation gradient from the coastal to the inland parts of the state, data from the nearest sites with complete records (Fairhope, AL and Stuttgart, AR) were similarly processed. These data, along with the data for Stoneville, MS, were then graphed (Figures 17, 18, and 19) to visually show the evaporation regime across the state by comparing the annual patterns of daily maximum, average, and minimum values at the three sites.

Degree Day 60's (DD60's)

A degree day 60 (DD60) is a heat unit derived by calculating a daily mean temperature (°F) and subtracting from that value a base temperature of 60°F. The difference is the number of DD60's for that particular day. DD60's accumulated through a time period become an index to represent the thermal environment and can be used to forecast plant growth and development or heating and cooling requirements.

Daily maximum and minimum temperature data for the period 1951-1980 were retrieved from CD-ROM based on National Weather Service Cooperative Observation Network records available through Earth Info, Inc. (Climatedata, 1989). Stations were chosen based upon the quality and completeness of the records and to represent major agricultural producing areas of the state. Missing data were inserted into the records by using the measurement from the nearest station for the day in question. Therefore the data are serially complete and quality controlled.

Average daily temperatures were computed using the maximum and minimum data. These daily averages were then departed from the 60 °F threshhold to compute the daily heat units, which were then summed by 7-day periods based on standard climatological weeks of the average growing season for Mississippi. Probabilities for accumulation of DD60's for any given week during the growing season were computed by use of empirical quantile methods.

Tables 39-46 present the mean, maximum, and minimum DD60 accumulations as well as the standard deviations and probabilities at 10 levels for each week. For example, Table 39 shows that, for the week beginning May 3, the average weekly DD60 accumulation at Canton, MS is 60, the maximum and minimum accumulation over the 30-year period is 110 and 2, respectively. The standard deviation for that week is 27.7. The table shows that there is a 90% chance of receiving at most 94 units, and, reading from the bottom, a 90% chance of receiving at least 27 units.

The tables can also be used to assess the accumulated amounts of heat units for given time periods through the growing season at stated levels of probability by summing within columns. For example, Table 39 can be used to find that at most 992 units accumulate by the end of June at Canton, MS at the 50% probability level. For that same time period, the table shows that at most 1,225 units can be expected 90% of the time.

Water Temperature

With the rapid expansion of commercial aquaculture in the state in recent years, the need for a climatological data base of water temperatures is apparent. A 36-year record of pond water temperatures has been derived by establishing a relationship between existing air and water temperature records (Wax et al., 1987). Figure 20 shows the daily average morning and afternoon pond temperatures (°F) at Stoneville, MS as derived from the predictive model. The figure shows that afternoon pond temperatures average above 60 °F for about 9 months, and that morning pond temperatures average above 60 °F for about 8 months each year. The figure also shows that average pond temperatures do not exceed 88 °F nor fall below 47 °F.

Water Balance

Evaluation of the daily amounts of water added to landscapes by precipitation and lost from landscapes by evaporation provides an accounting of moisture fluctuations resulting from climatic processes. Such a water balance approach has been used to assess the impact of climatic variability on pond surfaces seasonally, annually, and spatially (Pote and Wax, 1988; Wax and Pote, 1990). The results of this method can also be used to reveal the important interplay between precipitation and evaporation that characterizes the drying potential, field work potential, and wet-dry periods on a daily basis across the state.

Figures 21, 22, and 23 show results of a daily comparison of precipitation (P) and evaporation (E) at Fairhope, AL, Stoneville, MS, and Stuttgart, AR for the period 1962-1986. These sites were chosen to illustrate the coastal-to-inland gradient in the water balance existing across the state. For each day, loss of moisture by evaporation and gain of moisture by precipitation were computed and cumulatively summed through the period. Cumulative patterns of P-E for the average year, the wettest year, and the driest year of the 26-year period were graphed for each location.

Comparison of results at the different locations documents the potential for precipitation to exceed

evaporation on a cumulative basis through the year across the state, and illustrates the differing and sometimes extreme amounts of climatic variability experienced in the state on a day-to-day and an annual basis. For example, the cumulative curve of the average year at each site shows that P exceeds E all year in the coastal environment (Fairhope), but that E begins to exceed P in the central (Stoneville) and northern (Stuttgart) parts of the state about the first of August and the middle of July, respectively. The figures also show that there are years when either P or E can dominate, on a cumulative daily basis through an entire year at all locations because P-E is consistently positive or negative.

Crop Water Demand

Quantifying crop water demand involves two steps: (1) estimating potential evapotranspiration (PE) to represent the demand of the atmosphere for water; and (2) modifying the PE by use of crop coefficients to account for the physiological demand of different crops at different phenoloical stages. Pote and Wax (1986) calculated crop water demand for five Mississippi crops using measured pan evaporation modified by a correction coefficient of 0.8 and further modified by crop coefficients as established by U.S. Department of Agriculture (SCS, 1970). Table 47 presents the water demands of those crops on a weekly basis throughout their growing seasons in Mississippi based on their emergence dates.

Data Not Included

This document has been prepared in response to the many requests for weather and climate information directed to MAFES scientists and the State Climatologist. Many such requests are for data that do not exist or are not available at the time and space resolution needed. Wind, humidity, dew point temperatures, amount and types of cloud cover, and many other characteristics of the atmosphere are observed and archived for publication at only three sites in Mississippi – the first-order weather stations of the National Weather Service at Jackson, Meridian, and Tupelo. Hourly or shorter-period observations are likewise limited in the state.

Many observations of the above variables are made in the state by privately-owned weather stations, by networks associated with research projects, and by other public and private agencies. However, these data are not routinely stored in data sets and none are published. They are, therefore, effectively unavailable to the general public and have not been included in this document. It is anticipated that some of these presently unavailable data will become more routinely available in the future, but there is currently no good mechanism for storing, retrieving, quality controlling, and publishing these data.

References Cited

Climatedata. 1989. Climatedata Summary of the Day. Earthinfo, Inc., Boulder, CO.

Duffie, J. A., and W. A. Beckman. 1980. Solar Engineering of Thermal Processes. John Wiley and Sons, NY, p.14.

Lotus®. 1986. Lotus 1-2-3, Release 2.01. Lotus Developement Corporation, Cambridge, MA.

NCDC. 1985. Climatography of the United States Number 20 – Mississippi. National Climatic Data Center, Asheville, NC.

Pote, J. W., and C. L. Wax. 1986. Climatological Aspects of Irrigation Design Criteria in Mississippi. Technical Bulletin 138, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Pote, J. W., C. L. Wax, and C. S. Tucker. 1988. Water Conservation in Catfish Production: Sources, Uses, and Conservation. Special Bulletin 88-3, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Soil Conservation Service. 1970. Irrigation Water Requirements, Technical Release No. 21. U.S. Department of Agriculture, Washington, DC.

Wax, C. L., J. W. Pote, and N. C. Deliman. 1987. A Climatology of Pond Temperatures for Aquaculture in Mississippi. Technical Bulletin 149, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Wax, C. L., and J. W. Pote. 1990. A Climatological Basis for Conservation of Groundwater in Aquaculture in the Southern Region. Technical Bulletin 169, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS.

Appendix A
Data Tables

Table 1. Monthly total precipitation (inches), 1960-89, Climate Division 1 (Cleveland, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	5.83	4.15	5.78	3.28	4.55	4.27	2.77	2.37	4.52	4.73	3.81	6.47	52.53	4.38	6.47	2.37
1961	2.52	13.06	13.82	3.90	4.21	4.80	9.16	3.40	2.88	2.06	9.70	14.96	84.47	7.04	14.96	2.06
1962	9.06	5.24	3.43	5.70	3.22	8.25	0.67	3.62	3.14	1.85	1.81	3.25	49.24	4.10	9.06	0.67
1963	2.32	1.83	5.89	4.65	1.59	4.98	8.09	3.14	2.50	0.17	4.07	6.26	45.49	3.79	8.09	0.17
1964	5.27	3.96	8.07	12.55	3.12	1.74	1.05	5.17	3.46	1.11	7.83	5.73	59.06	4.92	12.55	1.05
1965	2.99	8.45	7.20	4.01	8.29	1.68	4.32	2.33	7.37	0.67	1.24	1.33	49.88	4.16	8.45	0.67
1966	4.39	9.21	0.72	4.13	3.18	2.25	4.96	2.82	3.53	5.35	0.89	6.76	48.19	4.02	9.21	0.72
1967	1.60	3.68	3.87	4.71	8.00	1.51	5.23	1.61	2.01	1.51	1.73	9.54	45.00	3.75	9.54	1.51
1968	8.89	1.82	7.07	6.77	9.10	0.97	7.08	2.08	7.63	2.58	9.13	6.71	69.83	5.82	9.13	0.97
1969	2.25	5.44	4.62	8.70	4.04	1.01	1.57	1.86	2.94	1.52	6.35	8.83	49.13	4.09	8.83	1.01
1970	2.17	4.26	7.73	11.48	3.21	4.77	5.29	10.03	1.37	7.59	2.57	3.84	64.31	5.36	11.48	1.37
1971	3.79	6.01	4.54	4.22	5.93	4.57	8.46	6.33	0.90	0.28	2.37	6.32	53.72	4.48	8.46	0.28
1972	7.15	1.07	5.38	4.96	3.37	4.59	5.57	1.49	4.11	3.56	9.63	7.24	58.12	4.84	9.63	1.07
1973	6.76	4.12	18.12	8.59	5.00	4.03	6.42	1.51	2.18	5.45	7.61	6.02	75.81	6.32	18.12	1.51
1974	11.54	5.43	4.79	5.34	6.97	11.04	3.01	7.33	5.94	3.14	3.12	5.14	72.79	6.07	11.54	3.01
1975	5.23	9.31	10.79	4.64	16.68	3.89	2.01	3.87	2.70	2.64	6.16	4.13	72.05	6.00	16.68	2.01
1976	4.28	5.62	8.48	3.50	4.24	4.90	6.36	0.65	1.45	5.25	3.00	2.74	50.47	4.21	8.48	0.65
1977	3.08	1.53	7.33	7.51	0.21	1.64	2.84	0.95	3.68	2.38	7.14	3.00	41.29	3.44	7.51	0.21
1978	5.81	2.46	2.07	3.05	11.45	4.86	3.35	2.75	1.41	1.34	4.66	8.18	51.39	4.28	11.45	1.34
1979	10.53	4.65	7.79	11.43	8.34	4.59	5.12	1.92	6.66	3.73	6.20	2.80	73.76	6.15	11.43	1.92
1980	3.88	2.64	12.20	6.97	5.80	4.70	2.46	0.18	7.65	2.58	3.90	0.80	53.76	4.48	12.20	0.18
1981	2.23	2.31	5.41	1.10	5.62	4.37	4.64	2.35	2.36	3.86	1.58	1.88	37.71	3.14	5.62	1.10
1982	4.70	4.37	1.28	7.73	6.03	5.69	1.82	5.03	2.88	6.36	5.98	19.55	71.42	5.95	19.55	1.28
1983	2.40	6.66	5.78	5.27	9.02	4.65	4.45	1.42	5.14	1.50	7.36	13.48	67.13	5.59	13.48	1.42
1984	2.49	5.82	6.21	8.59	5.90	1.59	3.05	2.99	0.55	10.64	4.62	0.87	53.32	4.44	10.64	0.55
1985	4.19	3.98	3.16	3.74	1.73	4.38	3.29	4.37	3.62	7.03	2.42	3.30	45.21	3.77	7.03	1.73
1986	0.38	1.76	1.89	2.30	5.40	5.25	1.85	4.37	0.50	5.18	11.07	4.20	44.15	3.68	11.07	0.38
1987	3.09	7.91	4.74	1.75	7.46	5.05	5.54	3.17	2.95	0.15	9.57	2.37	53.75	4.48	9.57	0.15
1988	1.29	5.83	2.87	0.37	0.00	3.49	0.95	7.81	4.13	5.62	7.67	5.62	45.65	3.80	7.81	0.00
1989	2.45	7.05	2.78	1.89	9.01	10.41	12.55	0.33	3.05	1.15	4.30	2.15	57.12	4.76	12.55	0.33
Mean	4.42	4.99	6.13	5.43	5.69	4.33	4.46	3.24	3.44	3.37	5.25	5.78	56.53			
Max	11.54	13.06	18.12	12.55	16.68	11.04	12.55	10.03	7.65	10.64	11.07	19.55	84.47			
Min	0.38	1.07	0.72	0.37	0.00	0.97	0.67	0.18	0.50	0.15	0.89	0.80	37.71			
SDEV	2.72	2.68	3.74	3.02	3.40	2.36	2.70	2.26	1.96	2.48	2.88	4.18	11.71			

Table 2. Monthly total precipitation (inches), 1960-89, Climate Division 2 (Oxford, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	5.03	3.88	6.87	2.23	4.27	3.16	3.81	5.70	3.53	5.53	2.95	3.68	50.64	4.22	6.87	2.23
1961	1.87	7.90	10.29	3.09	4.75	2.64	3.68	1.43	2.59	1.47	10.19	9.33	59.23	4.94	10.29	1.43
1962	9.23	6.44	2.78	4.64	3.16	8.44	3.31	2.65	5.39	2.33	2.08	2.20	52.65	4.39	9.23	2.08
1963	1.15	2.39	4.70	8.11	2.23	1.57	11.76	1.34	2.31	0.00	3.00	5.00	43.56	3.63	11.76	0.00
1964	4.11	3.18	7.80	9.22	2.04	2.06	6.71	3.02	4.48	1.39	4.62	7.24	55.87	4.66	9.22	1.39
1965	3.77	8.50	8.25	1.41	2.71	0.56	1.64	4.96	3.80	0.79	2.91	2.81	42.11	3.51	8.50	0.56
1966	2.45	7.54	1.91	5.73	4.93	1.06	2.97	4.58	3.99	4.51	2.62	6.39	48.68	4.06	7.54	1.06
1967	1.56	3.41	2.90	4.36	7.91	1.97	5.25	5.23	3.26	2.32	3.44	6.69	48.30	4.03	7.91	1.56
1968	6.99	1.84	6.67	6.49	7.46	0.90	2.65	3.24	10.02	3.60	9.01	5.36	64.23	5.35	10.02	0.90
1969	2.05	5.21	3.22	6.53	2.69	4.98	1.47	3.39	3.02	1.94	6.80	7.72	49.02	4.09	7.72	1.47
1970	1.44	4.42	8.68	10.61	8.35	4.06	2.94	1.42	0.86	5.00	2.71	2.34	52.83	4.40	10.61	0.86
1971	6.03	6.33	3.70	3.74	4.14	2.75	5.68	2.65	3.83	2.25	1.19	5.52	47.86	3.99	6.33	1.19
1972	6.92	0.93	4.39	3.40	5.81	6.26	2.89	4.76	5.52	2.88	9.70	7.79	61.25	5.10	9.70	0.93
1973	7.65	3.67	16.07	7.02	5.33	2.76	3.60	4.94	2.59	4.20	11.53	4.50	73.86	6.16	16.07	2.59
1974	12.65	5.00	3.00	4.12	11.06	10.76	4.11	5.59	3.76	2.51	2.75	7.55	72.86	6.07	12.65	2.51
1975	4.24	4.91	11.31	3.31	6.15	3.46	4.62	3.80	2.15	2.24	5.36	3.24	54.79	4.57	11.31	2.15
1976	5.15	5.57	6.38	1.06	5.19	3.61	3.20	1.34	5.68	4.07	2.38	2.50	46.13	3.84	6.38	1.06
1977	2.80	2.41	6.76	4.64	2.50	1.46	5.17	1.62	9.22	3.90	9.86	2.47	52.81	4.40	9.86	1.46
1978	5.53	1.09	2.92	3.73	13.00	4.22	1.04	4.06	1.29	2.00	5.28	8.09	52.25	4.35	13.00	1.04
1979	9.75	3.87	6.86	7.93	10.88	2.55	5.66	3.63	4.89	2.43	8.64	4.59	71.68	5.97	10.88	2.43
1980	4.74	1.16	12.30	3.82	2.10	3.36	0.97	1.18	5.48	3.95	4.55	0.48	48.09	4.01	12.30	0.48
1981	1.20	3.60	5.65	1.82	5.11	2.06	7.08	1.09	1.31	2.88	1.81	2.77	36.38	3.03	7.08	1.09
1982	5.21	4.46	1.32	8.53	1.94	5.59	3.87	6.81	3.75	10.36	5.06	19.93	76.83	6.40	19.93	1.32
1983	3.50	5.30	4.61	10.36	10.66	2.91	1.56	0.73	4.51	3.76	10.22	10.57	68.69	5.72	10.66	0.73
1984	2.40	3.38	5.40	4.83	9.37	0.22	2.53	2.86	0.71	12.94	6.66	2.03	53.33	4.44	12.94	0.22
1985	3.37	5.02	2.86	3.82	6.02	4.26	6.85	6.40	3.07	4.44	2.65	2.04	50.80	4.23	6.85	2.04
1986	0.34	1.73	3.00	2.00	7.26	5.36	1.85	4.59	2.15	5.62	10.70	7.24	51.84	4.32	10.70	0.34
1987	2.21	6.94	3.66	2.63	4.51	3.62	3.34	1.25	2.36	0.93	7.21	6.51	45.17	3.76	7.21	0.93
1988	3.86	3.65	4.15	4.11	2.98	0.22	7.00	0.46	7.26	4.97	4.58	4.15	47.39	3.95	7.26	0.22
1989	11.60	11.04	5.18	2.05	6.20	9.95	10.47	2.45	3.10	1.21	7.15	2.90	73.30	6.11	11.60	1.21
Mean	4.63	4.49	5.79	4.98	5.69	3.56	4.26	3.24	3.86	3.55	5.59	5.45	55.08			
Max	12.65	11.04	16.07	10.61	13.00	10.76	11.76	6.81	10.02	12.94	11.53	19.93	76.83			
Min	0.34	0.93	1.32	1.06	1.94	0.22	0.97	0.46	0.71	0.00	1.19	0.48	36.38			
SDEV	3.07	2.32	3.32	2.65	2.99	2.57	2.53	1.79	2.15	2.62	3.09	3.66	10.43			

Table 3. Monthly total precipitation (inches), 1960-89, Climate Division 3 (Corinth, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	5.38	3.41	5.40	2.17	2.62	2.11	2.28	4.10	4.05	3.88	2.56	4.08	42.04	3.50	5.40	2.11
1961	1.12	6.37	7.91	4.12	2.52	4.74	3.28	0.89	0.91	1.69	6.43	10.28	50.26	4.19	10.28	0.89
1962	9.38	8.96	3.01	4.53	3.46	4.39	2.22	1.32	4.24	1.51	1.93	1.62	46.57	3.88	9.38	1.32
1963	1.67	3.39	5.66	4.17	5.32	4.75	5.76	2.18	0.35	0.00	3.59	3.46	40.30	3.36	5.76	0.00
1964	4.31	4.10	8.02	9.58	1.96	1.94	7.72	3.67	3.76	1.99	4.57	0.15	51.77	4.31	9.58	0.15
1965	5.32	9.74	3.38	2.54	4.50	1.08	2.00	3.13	1.11	1.74	2.07	2.07	38.68	3.22	9.74	1.08
1966	3.91	8.06	0.77	2.38	5.67	0.00	4.77	3.60	2.66	3.02	2.12	6.25	43.21	3.60	8.06	0.00
1967	1.80	3.80	2.20	5.95	10.20	0.56	7.62	4.35	1.96	4.22	2.49	8.62	53.77	4.48	10.20	0.56
1968	6.64	0.80	6.55	4.60	5.17	2.09	3.25	3.23	4.69	4.15	4.96	4.15	50.28	4.19	6.64	0.80
1969	2.92	6.28	3.47	11.09	4.58	3.32	3.59	6.87	3.83	6.00	7.26	7.26	66.47	5.54	11.09	2.92
1970	1.84	4.34	7.58	9.46	3.00	5.12	1.70	1.19	2.07	7.78	2.44	4.17	50.69	4.22	9.46	1.19
1971	4.98	5.11	3.91	4.07	2.72	3.36	5.44	4.82	5.58	1.02	1.64	6.35	49.00	4.08	6.35	1.02
1972	5.67	4.71	4.12	2.80	3.57	3.75	4.03	2.78	5.98	3.90	9.91	7.85	59.07	4.92	9.91	2.78
1973	6.06	5.31	17.88	8.23	7.23	4.72	2.08	3.08	0.73	3.33	11.94	4.47	75.06	6.26	17.88	0.73
1974	11.89	4.70	2.43	3.07	8.01	7.20	5.86	4.47	4.18	2.54	5.01	6.52	65.88	5.49	11.89	2.43
1975	5.57	5.94	9.34	4.30	6.89	1.03	7.17	4.11	3.57	4.25	3.77	2.74	58.68	4.89	9.34	1.03
1976	3.90	4.15	6.01	4.58	5.92	1.72	3.39	0.26	5.03	6.91	2.21	2.61	46.69	3.89	6.91	0.26
1977	3.52	2.68	6.74	6.66	2.05	4.35	2.51	3.34	9.30	4.15	10.74	3.20	59.24	4.94	10.74	2.05
1978	5.08	0.76	5.25	3.09	8.10	3.45	1.01	1.52	0.82	1.01	5.51	8.50	44.10	3.68	8.50	0.76
1979	7.66	3.84	5.77	8.71	7.29	2.95	5.49	3.77	8.50	2.06	9.14	5.20	70.38	5.87	9.14	2.06
1980	3.88	1.74	13.95	6.24	5.61	5.41	1.37	2.65	5.12	2.40	5.05	0.56	53.98	4.50	13.95	0.56
1981	1.56	3.44	4.60	4.54	5.86	1.88	5.63	1.79	2.45	3.61	3.93	2.08	41.37	3.45	5.86	1.56
1982	6.38	3.86	5.88	6.19	4.29	1.50	5.33	4.11	2.57	2.73	5.96	12.13	60.93	5.08	12.13	1.50
1983	3.26	5.03	3.84	9.80	11.42	2.76	0.89	2.01	2.24	3.04	10.02	10.02	64.33	5.36	11.42	0.89
1984	1.91	2.89	7.30	8.71	5.78	2.79	2.96	1.24	1.26	6.24	6.71	2.54	50.33	4.19	8.71	1.24
1985	3.32	3.48	2.58	4.86	2.19	4.31	6.12	3.95	6.06	4.22	3.60	1.02	45.71	3.81	6.12	1.02
1986	0.36	4.33	4.06	0.56	5.63	6.95	1.61	5.71	2.65	4.15	10.03	6.64	52.68	4.39	10.03	0.36
1987	2.02	7.11	2.42	2.18	5.76	4.70	2.47	2.06	2.70	0.48	5.31	5.43	42.64	3.55	7.11	0.48
1988	3.32	2.97	3.70	4.66	3.59	0.00	5.48	1.50	5.02	4.70	7.50	4.70	47.14	3.93	7.50	0.00
1989	9.98	7.99	4.83	3.83	5.22	6.18	8.86	2.27	12.33	1.94	4.01	2.72	70.16	5.85	12.33	1.94
Mean	4.49	4.64	5.62	5.26	5.20	3.30	4.06	3.00	3.86	3.29	5.41	4.91	53.05			
Max	11.89	9.74	17.88	11.09	11.42	7.20	8.86	6.87	12.33	7.78	11.94	12.13	75.06			
Min	0.36	0.76	0.77	0.56	1.96	0.00	0.89	0.26	0.35	0.00	1.64	0.15	38.68			
SDEV	2.68	2.15	3.42	2.64	2.29	1.90	2.17	1.48	2.66	1.84	2.93	2.99	9.75			

Table 4. Monthly total precipitation (inches), 1960-89, Climate Division 4 (Greenville, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	5.41	4.34	4.19	3.30	4.71	1.71	1.78	6.55	2.51	2.98	3.85	6.05	47.38	3.95	6.55	1.71
1961	1.49	10.77	11.65	3.89	3.00	5.55	9.58	2.79	1.66	2.11	10.16	11.92	74.57	6.21	11.92	1.49
1962	6.71	3.02	2.32	4.02	4.35	1.26	0.38	3.07	3.12	3.23	3.06	2.98	37.52	3.13	6.71	0.38
1963	2.16	2.28	4.82	3.11	2.86	5.75	5.93	0.71	2.26	0.00	4.10	5.20	38.98	3.25	5.93	0.00
1964	2.56	2.38	6.23	0.98	2.62	0.50	2.84	2.83	2.96	0.84	5.18	5.70	35.82	2.97	6.23	0.50
1965	2.11	7.93	5.75	3.38	3.59	2.36	1.66	1.83	5.20	1.18	1.88	1.56	38.43	3.20	7.93	1.18
1966	3.84	9.05	0.38	3.87	3.51	2.38	2.86	3.72	1.42	3.01	2.07	5.91	42.02	3.50	9.05	0.38
1967	1.45	5.17	1.85	2.96	6.77	1.93	5.71	2.49	1.50	1.30	2.51	7.77	41.41	3.45	7.77	1.30
1968	10.66	1.51	5.01	6.45	6.23	1.15	4.03	4.10	9.52	3.41	8.88	6.63	67.58	5.63	10.66	1.15
1969	1.80	3.66	4.73	6.01	3.54	3.18	5.82	1.13	1.27	1.83	8.69	8.78	50.44	4.20	8.78	1.13
1970	1.61	3.72	7.23	8.86	3.96	2.01	3.09	4.84	2.38	8.47	2.59	5.05	53.81	4.48	8.86	1.61
1971	4.82	6.84	4.79	2.71	7.07	1.96	9.55	3.14	2.11	0.32	2.82	6.74	52.87	4.41	9.55	0.32
1972	8.11	0.41	4.99	4.49	2.34	4.09	4.16	0.66	3.01	4.10	9.44	8.01	53.81	4.48	9.44	0.41
1973	6.30	15.83	7.18	3.73	3.51	0.27	2.27	4.46	9.70	5.27	9.70	5.27	73.49	6.12	15.83	0.27
1974	11.53	3.94	4.71	9.15	7.69	7.70	3.49	7.92	3.76	4.02	3.53	5.98	73.42	6.12	11.53	3.49
1975	5.02	11.35	10.75	6.74	12.48	5.26	2.70	4.86	2.51	2.54	5.15	2.22	71.58	5.97	12.48	2.22
1976	5.91	4.36	7.77	1.01	4.75	7.82	3.67	0.23	4.81	3.60	2.87	3.57	50.37	4.20	7.82	0.23
1977	3.86	1.53	6.20	4.44	1.49	1.20	3.30	1.34	5.49	3.12	7.58	3.32	42.87	3.57	7.58	1.20
1978	5.83	2.84	2.11	3.18	12.62	4.53	2.92	4.23	1.93	1.21	4.41	8.40	54.21	4.52	12.62	1.21
1979	12.26	4.13	5.53	11.73	8.91	4.69	2.17	4.84	3.57	7.25	3.18	3.18	71.44	5.95	12.26	2.17
1980	4.46	2.71	12.13	9.01	6.24	3.23	0.61	1.71	4.08	2.79	2.84	0.49	50.30	4.19	12.13	0.49
1981	1.89	2.51	4.83	0.98	4.91	4.76	2.17	1.99	2.18	3.40	2.59	2.55	34.76	2.90	4.91	0.98
1982	3.45	5.03	2.03	5.73	0.57	8.62	2.98	3.67	4.12	7.44	6.01	19.34	68.99	5.75	19.34	0.57
1983	1.89	7.33	4.10	4.91	9.15	5.83	1.40	0.05	1.98	0.77	11.37	10.70	59.48	4.96	11.37	0.05
1984	3.36	6.66	6.26	6.99	5.78	5.73	4.34	2.78	0.80	10.02	6.22	0.86	59.80	4.98	10.02	0.80
1985	4.69	4.67	3.93	3.23	0.74	3.99	2.20	4.43	2.51	5.91	3.54	3.27	43.11	3.59	5.91	0.74
1986	0.27	2.14	2.19	3.53	0.68	1.10	1.30	4.35	19.56	3.58	19.56	3.58	61.84	5.15	19.56	0.27
1987	3.09	8.51	3.57	3.52	6.39	4.44	2.49	1.64	0.28	0.17	10.46	4.83	49.39	4.12	10.46	0.17
1988	1.50	2.51	6.60	2.77	0.56	0.99	2.34	1.67	3.60	5.14	3.82	5.06	36.56	3.05	8.60	0.56
1989	6.91	5.14	2.84	4.77	5.04	9.24	11.12	1.07	4.33	0.40	3.38	5.21	59.45	4.95	11.12	0.40
Mean	4.50	5.08	5.22	4.65	4.87	3.77	3.63	2.97	3.80	3.31	5.71	5.67	53.18			
Max	12.26	15.83	12.13	11.73	12.62	9.24	11.12	7.92	19.56	10.02	19.56	19.34	74.57			
Min	0.27	0.41	0.38	0.98	0.56	0.27	0.38	0.05	0.28	0.00	1.88	0.49	34.76			
SDEV	3.02	3.37	2.74	2.51	3.09	2.46	2.54	1.84	3.60	2.50	3.84	3.67	12.57			

Table 5. Monthly total precipitation (inches), 1960-89, Climate Division 5 (Forest, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	5.40	3.67	4.98	2.78	6.32	1.15	2.10	12.23	1.03	4.51	1.28	3.17	48.62	4.05	12.23	1.03
1961	4.26	10.10	12.76	2.02	2.05	13.85	7.14	2.55	0.96	0.58	8.45	10.89	75.61	6.30	13.85	0.58
1962	8.87	2.71	2.83	6.34	1.69	4.48	0.47	4.43	2.63	3.01	2.84	3.03	43.33	3.61	8.87	0.47
1963	7.12	2.27	4.90	3.34	0.31	3.26	5.63	5.40	3.55	0.15	2.99	3.52	42.44	3.54	7.12	0.15
1964	6.45	3.21	7.98	10.05	1.91	5.08	5.24	5.54	6.19	7.56	5.65	7.28	72.14	6.01	10.05	1.91
1965	2.78	5.22	5.77	0.68	0.82	3.96	7.63	5.16	8.31	1.90	1.75	2.96	46.94	3.91	8.31	0.68
1966	7.20	8.51	1.59	5.91	7.48	3.96	7.15	4.11	4.15	4.90	3.63	7.03	65.62	5.47	8.51	1.59
1967	1.92	3.32	2.76	1.61	10.86	1.08	6.55	3.46	2.63	3.06	0.84	11.08	49.17	4.10	11.08	0.84
1968	5.80	1.43	6.45	5.00	6.29	3.90	4.32	6.64	2.65	1.23	5.15	9.28	58.14	4.85	9.28	1.23
1969	1.81	3.16	6.31	6.81	5.16	1.06	8.98	4.57	1.77	1.64	2.37	6.92	50.56	4.21	8.98	1.06
1970	3.16	3.04	5.15	4.08	5.71	3.00	4.38	6.35	2.70	8.14	1.63	5.14	52.48	4.37	8.14	1.63
1971	4.07	6.90	8.77	4.45	6.08	5.36	7.84	1.38	5.56	1.01	2.32	11.63	65.37	5.45	11.63	1.01
1972	8.60	3.63	5.96	1.82	2.78	4.16	5.70	0.79	4.97	5.37	3.86	8.43	56.07	4.67	8.60	0.79
1973	4.00	5.90	10.44	9.35	6.85	1.59	5.25	6.53	5.71	3.56	6.61	7.26	73.05	6.09	10.44	1.59
1974	11.54	6.72	3.45	10.98	4.18	3.59	3.45	7.44	6.39	2.01	6.55	10.51	76.81	6.40	11.54	2.01
1975	6.25	6.65	4.73	6.17	7.59	3.12	4.31	7.06	4.82	7.66	2.30	3.85	64.51	5.38	7.66	2.30
1976	2.86	1.50	14.66	0.46	6.74	3.27	5.11	3.22	3.47	2.96	3.75	4.25	52.25	4.35	14.66	0.46
1977	7.30	3.70	10.12	7.52	2.57	2.17	11.09	3.81	8.01	5.22	9.57	2.93	74.01	6.17	11.09	2.17
1978	5.43	1.69	3.26	3.82	7.39	4.77	4.34	2.47	0.61	0.78	3.68	8.74	46.98	3.92	8.74	0.61
1979	13.29	6.81	6.33	10.17	7.10	4.23	12.58	5.82	8.76	1.52	6.32	5.42	88.35	7.36	13.29	1.52
1980	6.12	2.93	14.89	9.05	4.40	3.15	4.34	2.44	2.21	4.92	7.69	1.11	63.25	5.27	14.89	1.11
1981	1.78	3.78	7.74	4.88	4.91	4.07	3.89	3.40	4.01	5.51	2.43	6.69	53.09	4.42	7.74	1.78
1982	4.63	6.72	4.24	5.64	1.05	5.12	6.69	5.61	0.24	4.12	5.62	12.22	61.90	5.16	12.22	0.24
1983	7.23	8.24	6.68	9.91	11.41	4.89	0.32	2.83	2.20	2.31	6.75	8.47	71.24	5.94	11.41	0.32
1984	3.56	5.70	4.24	4.89	5.29	0.48	7.12	6.58	0.75	8.49	7.40	2.02	56.52	4.71	8.49	0.48
1985	3.63	8.39	3.09	3.72	1.05	4.49	2.80	3.59	5.01	10.19	1.24	3.95	51.15	4.26	10.19	1.05
1986	0.79	2.54	4.99	1.98	10.66	5.27	6.20	2.38	4.66	5.64	11.29	3.59	59.99	5.00	11.29	0.79
1987	5.62	12.54	5.46	0.82	6.01	4.53	1.39	4.60	2.44	0.13	3.63	3.78	50.95	4.25	12.54	0.13
1988	2.12	4.50	5.49	6.16	0.97	0.24	4.03	7.63	4.48	6.93	8.95	4.40	55.90	4.66	8.95	0.24
1989	6.14	2.65	6.30	2.64	6.86	7.86	8.35	0.44	7.02	1.74	8.39	5.13	63.52	5.29	8.39	0.44
Mean	5.32	4.94	6.41	5.10	5.08	3.90	5.48	4.62	3.93	3.89	4.83	6.16	59.67			
Max	13.29	12.54	14.89	10.98	11.41	13.85	12.58	12.23	8.76	10.19	11.29	12.22	88.35			
Min	0.79	1.43	1.59	0.46	0.31	0.24	0.32	0.44	0.24	0.13	0.84	1.11	42.44			
SDEV	2.82	2.70	3.28	3.03	3.02	2.48	2.75	2.39	2.32	2.71	2.80	3.08	11.12			

Table 6. Monthly total precipitation (inches), 1960-89, Climate Division 6 (Mississippi State University, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	7.05	3.88	7.65	1.77	3.25	1.99	1.39	2.79	1.39	4.45	3.17	3.60	42.38	3.53	7.65	1.39
1961	1.69	7.68	9.37	4.44	2.19	7.55	5.75	1.22	1.60	3.48	10.46	14.13	69.56	5.80	14.13	1.22
1962	7.43	4.83	5.47	5.54	2.54	3.35	3.55	2.09	1.24	2.37	3.03	2.61	44.05	3.67	7.43	1.24
1963	4.43	2.26	3.36	3.42	3.24	2.95	10.01	1.40	1.20	0.30	4.81	5.01	42.39	3.53	10.01	0.30
1964	5.30	2.88	7.57	10.84	4.21	3.92	4.07	4.53	5.50	1.13	3.53	5.78	59.26	4.94	10.84	1.13
1965	2.52	7.91	5.92	4.43	0.87	3.29	5.54	3.85	8.66	2.95	0.48	1.27	47.69	3.97	8.66	0.48
1966	5.62	6.41	1.69	6.92	2.64	2.24	3.19	2.75	4.33	2.67	1.65	4.08	44.19	3.68	6.92	1.65
1967	1.87	4.49	1.63	2.32	4.96	2.00	10.40	4.35	2.25	3.05	2.71	13.64	53.67	4.47	13.64	1.63
1968	6.83	2.35	4.44	5.46	3.43	1.71	7.47	5.89	5.26	0.95	4.50	5.73	54.02	4.50	7.47	0.95
1969	2.13	4.63	5.55	7.91	5.63	1.74	2.15	2.98	1.34	2.98	2.81	10.51	50.36	4.20	10.51	1.34
1970	2.28	2.71	5.74	8.78	4.55	2.73	3.02	8.80	2.28	5.51	1.85	2.71	50.96	4.25	8.80	1.85
1971	3.02	9.96	6.25	5.39	7.62	5.26	7.21	3.92	6.57	1.68	1.63	8.95	67.46	5.62	9.96	1.63
1972	8.43	1.49	5.11	2.36	3.66	6.45	4.64	1.42	5.56	2.69	5.07	8.00	54.88	4.57	8.43	1.42
1973	8.51	3.54	11.73	7.45	4.83	1.93	5.92	6.27	4.11	2.47	6.17	6.22	69.15	5.76	11.73	1.93
1974	13.55	4.28	2.82	7.39	5.35	8.83	2.92	5.85	7.06	1.10	2.86	6.59	68.60	5.72	13.55	1.10
1975	6.37	6.30	10.19	4.22	5.12	3.52	2.42	6.58	2.45	5.38	2.75	4.00	59.30	4.94	10.19	2.42
1976	3.31	4.99	10.49	1.14	6.38	4.09	5.10	0.79	5.11	3.37	3.75	5.35	53.87	4.49	10.49	0.79
1977	5.56	2.30	10.95	9.20	0.33	1.21	7.63	0.84	1.23	5.93	8.05	2.11	55.34	4.61	10.95	0.33
1978	2.83	2.53	3.02	0.92	12.02	4.16	1.97	2.64	2.19	0.34	2.48	5.44	40.54	3.38	12.02	0.34
1979	9.68	6.46	5.92	16.47	4.16	1.45	9.51	3.64	10.36	2.27	6.77	2.62	79.31	6.61	16.47	1.45
1980	6.33	1.87	16.17	9.38	4.14	3.64	1.73	1.45	3.03	5.45	4.50	0.85	58.54	4.88	16.17	0.85
1981	1.60	3.38	0.87	2.60	4.14	3.56	2.54	2.61	2.10	3.01	1.68	3.48	31.57	2.63	4.14	0.87
1982	8.58	4.00	2.34	8.40	4.24	3.52	6.89	4.43	0.40	4.65	4.38	13.67	65.50	5.46	13.67	0.40
1983	5.02	10.17	6.96	11.48	12.21	5.91	3.16	0.97	5.76	3.07	7.69	13.35	85.75	7.15	13.35	0.97
1984	4.40	4.76	5.18	8.76	2.94	2.84	4.63	5.75	0.21	8.66	5.70	2.11	55.94	4.66	8.76	0.21
1985	3.13	5.97	2.36	3.48	2.39	3.78	2.97	3.95	1.05	9.40	1.39	3.04	42.91	3.58	9.40	1.05
1986	0.71	2.42	4.14	0.54	8.32	3.58	1.91	3.71	2.05	5.77	7.38	3.21	43.74	3.65	8.32	0.54
1987	4.72	8.29	4.61	1.35	3.83	3.85	1.92	3.07	1.27	0.20	3.99	4.12	41.22	3.44	8.29	0.20
1988	1.72	4.30	4.04	3.31	1.67	0.26	6.50	2.59	4.61	6.00	4.96	3.42	43.38	3.62	6.50	0.26
1989	9.76	5.48	4.09	3.78	7.08	8.45	6.30	2.40	7.46	0.39	6.36	4.73	66.28	5.52	9.76	0.39
Mean	5.15	4.75	5.85	5.65	4.60	3.66	4.75	3.45	3.59	3.39	4.22	5.68	54.73			
Max	13.55	10.17	16.17	16.47	12.21	8.83	10.40	8.80	10.36	9.40	10.46	14.13	85.75			
Min	0.71	1.49	0.87	0.54	0.33	0.26	1.39	0.79	0.21	0.20	0.48	0.85	31.57			
SDEV	3.00	2.29	3.41	3.66	2.69	2.03	2.55	1.92	2.60	2.31	2.28	3.79	12.36			

Table 7. Monthly total precipitation (inches), 1960-89, Climate Division 7 (Brookhaven, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	4.83	4.80	5.21	1.08	2.17	3.18	5.99	8.58	1.85	3.03	2.52	4.12	47.36	3.95	8.58	1.08
1961	8.38	7.61	15.85	2.08	1.69	7.64	5.20	1.98	2.42	1.07	8.44	11.04	73.40	6.12	15.85	1.07
1962	9.42	1.67	5.12	4.87	3.69	7.61	2.19	3.85	4.38	3.07	2.87	3.85	52.59	4.38	9.42	1.67
1963	8.55	3.46	3.17	1.29	2.31	4.08	5.57	3.90	1.27	0.00	3.42	6.54	43.56	3.63	8.55	0.00
1964	5.29	3.97	9.00	9.35	4.42	3.05	8.78	3.83	1.38	9.61	4.75	5.00	68.43	5.70	9.61	1.38
1965	1.90	5.03	6.54	0.33	2.19	4.62	5.07	7.69	4.29	0.99	3.30	4.74	46.69	3.89	7.69	0.33
1966	9.27	10.46	1.41	9.26	4.71	0.70	2.64	4.31	1.56	3.42	7.45	3.92	59.11	4.93	10.46	0.70
1967	2.20	4.88	2.83	4.03	8.91	2.52	7.63	5.97	3.01	4.13	0.69	10.76	57.56	4.80	10.76	0.69
1968	3.33	1.95	4.30	7.78	4.22	2.06	3.82	3.67	2.55	0.53	5.54	7.98	47.73	3.98	7.98	0.53
1969	0.99	3.39	6.84	9.09	3.50	1.91	4.68	3.69	3.30	5.25	1.51	6.22	50.37	4.20	9.09	0.99
1970	2.49	3.20	6.77	4.52	5.04	4.91	5.66	10.76	3.27	6.17	2.59	4.20	59.58	4.97	10.76	2.49
1971	1.43	8.72	9.06	3.72	5.84	3.15	3.65	2.23	6.47	0.50	2.02	14.81	61.60	5.13	14.81	0.50
1972	10.18	2.06	6.34	4.35	4.94	5.13	5.65	2.82	3.53	2.78	4.86	11.61	64.25	5.35	11.61	2.06
1973	3.32	6.10	13.87	8.80	7.00	5.01	3.77	7.26	4.74	2.80	8.98	6.56	78.21	6.52	13.87	2.80
1974	9.95	4.42	3.60	15.05	3.23	3.12	3.07	4.44	3.11	3.76	6.46	6.99	67.20	5.60	15.05	3.07
1975	6.88	5.25	6.28	5.35	11.63	6.56	5.97	5.61	4.31	3.58	4.28	4.12	69.82	5.82	11.63	3.58
1976	3.14	3.73	11.58	0.36	7.09	1.39	3.93	2.29	1.22	1.74	4.13	2.73	43.33	3.61	11.58	0.36
1977	5.59	4.19	7.16	9.19	0.89	0.55	4.01	6.55	4.05	5.41	8.42	3.43	59.44	4.95	9.19	0.55
1978	5.69	3.46	2.72	3.54	11.25	3.81	5.89	8.66	2.83	0.00	4.06	6.30	58.21	4.85	11.25	0.00
1979	9.46	8.66	4.63	11.12	3.30	2.16	10.84	5.01	3.26	1.50	8.44	5.05	73.43	6.12	11.12	1.50
1980	7.16	4.41	14.40	9.80	6.95	2.07	4.22	3.39	3.14	5.39	5.29	2.22	68.44	5.70	14.40	2.07
1981	1.49	4.26	6.51	2.47	7.43	5.57	5.43	0.97	4.84	1.80	1.50	5.12	47.39	3.95	7.43	0.97
1982	3.39	8.26	2.83	5.22	1.97	4.64	6.67	5.81	1.57	3.69	6.22	17.47	67.74	5.65	17.47	1.57
1983	5.73	9.00	5.16	15.23	8.01	7.94	0.65	5.55	2.48	1.21	5.55	8.31	74.82	6.24	15.23	0.65
1984	3.50	6.79	7.61	3.68	4.15	2.02	4.10	5.31	1.64	10.30	3.44	1.89	54.43	4.54	10.30	1.64
1985	4.41	6.66	3.85	4.83	2.03	4.29	4.71	6.33	6.87	11.64	0.35	4.68	60.65	5.05	11.64	0.35
1986	1.87	2.44	3.14	2.61	8.53	3.49	4.57	2.30	1.46	2.35	6.41	7.55	46.72	3.89	8.53	1.46
1987	7.67	12.84	4.46	1.24	7.42	4.57	2.65	4.38	5.05	0.49	3.15	3.51	57.43	4.79	12.84	0.49
1988	2.40	5.84	6.89	4.62	0.06	1.39	1.86	6.00	6.84	6.49	6.91	6.46	55.76	4.65	6.91	0.06
1989	6.15	2.19	6.38	1.78	7.21	7.39	6.15	0.64	8.53	1.09	3.44	6.84	57.79	4.82	8.53	0.64
Mean	5.20	5.32	6.45	5.55	5.06	3.88	4.83	4.79	3.51	3.46	4.57	6.47	59.10			
Max	10.18	12.84	15.85	15.23	11.63	7.94	10.84	10.76	8.53	11.64	8.98	17.47	78.21			
Min	0.99	1.67	1.41	0.33	0.06	0.55	0.65	0.64	1.22	0.00	0.35	1.89	43.33			
SDEV	2.86	2.68	3.50	3.98	2.91	2.06	2.02	2.31	1.84	2.97	2.36	3.54	9.74			

Table 8. Monthly total precipitation (inches), 1960-89, Climate Division 8 (Columbia, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	3.77	5.43	4.38	5.05	9.95	3.55	2.78	7.66	2.02	6.34	1.55	2.52	55.00	4.58	9.95	1.55
1961	9.44	20.92	13.74	2.76	2.68	7.02	3.64	6.37	3.50	1.60	13.34	10.89	95.90	7.99	20.92	1.60
1962	10.73	0.91	4.54	10.19	1.91	6.34	5.21	2.30	0.46	3.81	1.75	3.86	52.01	4.33	10.73	0.46
1963	5.88	3.43	3.16	0.50	2.41	4.05	5.45	3.69	1.70	0.19	3.77	5.75	39.98	3.33	5.88	0.19
1964	6.85	3.84	11.00	6.36	4.43	6.04	3.32	8.28	4.30	4.84	6.27	5.62	71.15	5.93	11.00	3.32
1965	5.63	8.45	4.00	1.49	1.42	3.82	4.79	5.52	3.43	0.63	4.46	5.34	48.98	4.08	8.45	0.63
1966	8.89	15.49	2.33	5.07	5.44	1.25	9.03	5.82	6.34	2.35	2.06	3.11	67.18	5.60	15.49	1.25
1967	2.87	5.90	1.43	4.03	7.17	3.82	3.73	4.74	2.76	1.60	0.72	7.55	46.32	3.86	7.55	0.72
1968	2.41	2.37	3.04	5.52	1.59	1.88	2.08	9.90	7.14	1.18	3.39	15.34	55.84	4.65	15.34	1.18
1969	1.49	4.73	6.49	6.58	4.70	0.98	5.92	11.38	1.72	1.07	1.35	6.15	52.56	4.38	11.38	0.98
1970	3.18	2.99	5.10	3.43	3.50	6.69	5.53	7.33	4.39	6.44	2.87	7.53	58.98	4.92	7.53	2.87
1971	2.49	6.22	6.94	1.22	6.06	4.90	11.64	2.06	5.80	0.16	5.05	14.14	66.68	5.56	14.14	0.16
1972	7.57	3.14	6.58	3.58	7.62	3.90	4.34	2.74	1.03	2.90	5.54	12.15	61.09	5.09	12.15	1.03
1973	4.02	3.51	11.92	12.41	6.10	4.14	6.96	3.11	4.84	2.43	6.52	12.24	78.20	6.52	12.41	2.43
1974	8.73	3.79	5.07	7.64	5.74	3.59	2.84	12.62	8.58	5.43	6.32	4.36	74.71	6.23	12.62	2.84
1975	12.68	5.45	7.88	5.80	8.26	5.85	8.16	5.15	5.55	2.97	2.80	3.84	74.39	6.20	12.68	2.80
1976	3.46	2.95	7.35	1.39	6.88	3.35	3.66	3.76	2.59	2.75	5.08	5.02	48.24	4.02	7.35	1.39
1977	5.19	2.99	5.56	7.40	0.87	1.40	5.70	5.97	7.02	6.16	7.80	4.18	60.24	5.02	7.80	0.87
1978	6.37	3.61	2.53	4.75	5.48	4.81	3.27	6.22	2.67	0.00	3.91	4.00	47.62	3.97	6.37	0.00
1979	10.66	10.71	3.60	10.38	4.14	0.83	8.36	5.68	4.86	1.13	4.39	4.51	69.25	5.77	10.71	0.83
1980	7.30	3.17	17.45	11.56	11.62	2.21	5.08	1.25	4.81	4.49	5.06	2.68	76.68	6.39	17.45	1.25
1981	1.07	5.69	5.22	0.90	4.11	1.84	7.75	2.00	7.07	1.42	7.94	7.94	52.95	4.41	7.94	0.90
1982	6.49	7.80	3.74	3.77	2.88	3.65	5.17	3.95	1.87	1.98	5.45	10.72	57.47	4.79	10.72	1.87
1983	6.54	9.97	7.20	21.79	6.20	10.93	3.36	3.39	3.03	1.22	5.65	8.38	87.66	7.31	21.79	1.22
1984	3.80	6.15	2.80	6.14	4.20	3.67	6.70	6.62	0.94	7.73	5.09	2.16	56.00	4.67	7.73	0.94
1985	5.30	7.00	5.01	3.14	2.62	1.92	6.84	8.74	5.79	10.17	1.15	5.00	62.68	5.22	10.17	1.15
1986	3.92	3.44	3.59	2.88	7.67	4.04	4.73	3.59	2.97	4.69	8.59	7.20	57.31	4.78	8.59	2.88
1987	8.15	10.84	6.90	1.72	8.51	5.22	2.36	17.98	1.75	0.30	4.95	4.04	72.72	6.06	17.98	0.30
1988	5.16	9.70	9.74	3.76	1.67	4.28	7.36	4.91	7.58	5.14	5.61	6.36	71.27	5.94	9.74	1.67
1989	6.01	2.74	9.48	1.97	13.00	7.84	6.13	5.55	6.94	1.14	7.76	6.67	75.23	6.27	13.00	1.14
Mean	5.87	6.11	6.26	5.44	5.29	4.13	5.40	5.94	4.12	3.08	4.87	6.64	63.14			
Max	12.68	20.92	17.45	21.79	13.00	10.93	11.64	17.98	8.58	10.17	13.34	15.34	95.90			
Min	1.07	0.91	1.43	0.50	0.87	0.83	2.08	1.25	0.46	0.00	0.72	2.16	39.98			
SDEV	2.83	4.20	3.59	4.35	2.99	2.21	2.18	3.50	2.23	2.51	2.62	3.44	12.74			

Table 9. Monthly total precipitation (inches), 1960-89, Climate Division 9 (Leakesville, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	3.53	4.81	9.14	3.20	8.03	0.63	5.37	4.01	5.22	4.88	1.07	3.46	53.35	4.45	9.14	0.63
1961	4.87	14.15	11.51	5.10	4.11	6.68	5.21	11.00	5.48	0.97	7.65	17.03	93.76	7.81	17.03	0.97
1962	4.36	2.82	6.79	6.07	2.05	6.35	3.12	3.78	3.40	2.96	2.63	2.55	46.88	3.91	6.79	2.05
1963	4.83	4.20	1.69	0.71	3.87	3.11	3.66	3.18	2.18	0.05	3.30	4.94	35.72	2.98	4.94	0.05
1964	6.95	3.55	6.18	7.60	3.85	5.08	8.11	4.96	2.96	4.62	4.64	5.11	63.61	5.30	8.11	2.96
1965	4.93	5.83	5.96	2.78	2.85	2.71	6.28	4.30	8.38	0.56	2.77	3.87	51.22	4.27	8.38	0.56
1966	6.38	12.15	3.00	5.00	3.80	0.97	4.47	6.29	2.04	2.91	3.24	3.36	53.61	4.47	12.15	0.97
1967	6.03	3.88	1.70	2.51	3.48	6.34	8.77	8.66	1.99	6.18	0.71	8.51	58.76	4.90	8.77	0.71
1968	2.87	2.00	2.67	4.23	3.20	1.90	4.28	7.00	4.68	4.46	4.07	6.75	48.11	4.01	7.00	1.90
1969	2.97	3.06	7.44	3.68	3.56	0.95	8.78	6.07	0.72	1.82	1.23	3.87	44.15	3.68	8.78	0.72
1970	3.34	4.21	8.68	1.54	3.57	3.34	6.66	5.96	4.17	6.26	2.55	8.41	58.69	4.89	8.68	1.54
1971	2.26	7.59	9.17	0.83	5.08	3.52	10.64	5.03	4.82	0.03	2.72	11.63	63.32	5.28	11.63	0.03
1972	10.27	3.47	9.17	3.20	8.10	3.23	5.51	1.87	5.30	2.28	5.13	8.47	66.00	5.50	10.27	1.87
1973	2.94	5.88	12.71	7.83	6.19	5.03	6.27	3.90	8.32	1.71	4.33	5.78	70.89	5.91	12.71	1.71
1974	5.75	2.99	6.42	10.90	1.87	8.31	4.67	5.69	8.24	1.27	5.65	5.75	67.51	5.63	10.90	1.27
1975	6.76	3.02	9.05	9.19	12.82	6.98	13.51	3.80	8.74	10.45	4.14	4.83	93.29	7.77	13.51	3.02
1976	1.50	3.27	5.05	2.96	8.12	3.96	4.82	1.93	4.18	4.48	6.02	4.62	50.91	4.24	8.12	1.50
1977	5.85	4.52	11.86	5.05	3.89	1.31	10.14	6.35	7.10	4.50	6.63	3.72	70.92	5.91	11.86	1.31
1978	7.48	3.29	2.55	4.41	8.40	12.91	7.70	6.39	2.54	0.00	2.73	3.98	62.38	5.20	12.91	0.00
1979	8.88	9.09	10.26	11.55	4.23	1.71	7.64	3.80	9.13	5.45	7.42	4.02	83.18	6.93	11.55	1.71
1980	5.10	2.45	14.01	12.09	17.24	3.25	3.23	4.05	5.14	4.35	2.89	1.62	75.42	6.29	17.24	1.62
1981	0.80	12.39	5.42	0.69	3.52	4.69	9.03	5.16	1.87	1.34	1.22	8.46	54.59	4.55	12.39	0.69
1982	5.31	8.97	2.71	5.21	1.35	7.52	7.85	6.17	5.82	1.47	6.17	8.35	66.90	5.58	8.97	1.35
1983	4.61	11.77	8.49	17.45	4.28	6.83	2.43	8.02	5.03	2.81	6.01	7.70	85.43	7.12	17.45	2.43
1984	4.61	6.30	4.59	3.08	8.12	4.14	2.76	6.19	0.47	5.02	3.99	3.34	52.61	4.38	8.12	0.47
1985	4.94	6.91	3.85	3.47	1.39	2.69	9.18	9.77	9.79	12.73	1.86	6.03	72.61	6.05	12.73	1.39
1986	2.81	4.39	6.52	2.88	5.74	2.48	5.45	6.60	2.37	2.12	9.27	4.54	55.17	4.60	9.27	2.12
1987	7.35	6.61	4.97	1.49	5.22	5.18	4.95	11.18	3.88	0.00	4.81	3.52	59.16	4.93	11.18	0.00
1988	4.92	6.19	8.76	3.23	0.61	2.00	10.32	4.19	18.17	4.49	4.52	2.87	70.27	5.86	18.17	0.61
1989	2.98	1.31	6.14	3.66	10.22	12.02	9.86	1.38	2.45	2.29	7.73	7.15	67.19	5.60	12.02	1.31
Mean	4.87	5.70	6.88	5.05	5.29	4.53	6.69	5.56	5.15	3.42	4.24	5.81	63.19			
Max	10.27	14.15	14.01	17.45	17.24	12.91	13.51	11.18	18.17	12.73	9.27	17.03	93.76			
Min	0.80	1.31	1.69	0.69	0.61	0.63	2.43	1.38	0.47	0.00	0.71	1.62	35.72			
SDEV	2.08	3.31	3.27	3.81	3.54	2.97	2.70	2.39	3.50	2.89	2.17	3.08	13.66			

Table 10. Monthly total precipitation (inches), 1960-89, Climate Division 10 (Poplarville, MS).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Mean	Max	Min
1960	4.11	6.02	6.08	3.58	3.28	2.13	4.71	8.03	2.95	4.68	1.82	4.49	51.88	4.32	8.03	1.82
1961	5.54	11.20	10.43	2.74	5.62	11.81	5.12	6.01	7.04	0.85	10.74	20.16	97.26	8.11	20.16	0.85
1962	5.80	2.93	5.29	4.98	1.79	6.61	2.63	3.17	1.16	4.89	2.43	4.53	46.21	3.85	6.61	1.16
1963	5.09	4.45	2.64	0.52	3.43	1.53	5.66	6.19	2.93	0.21	2.92	5.62	41.19	3.43	6.19	0.21
1964	5.99	4.36	6.72	8.81	4.84	7.37	8.82	5.67	4.38	4.90	3.80	7.51	73.17	6.10	8.82	3.80
1965	6.66	7.12	3.53	1.30	1.06	2.36	7.73	7.22	4.92	1.05	3.74	3.84	50.53	4.21	7.73	1.05
1966	10.08	14.32	3.17	5.86	3.53	5.86	7.69	7.93	3.70	2.68	3.37	4.31	72.50	6.04	14.32	2.68
1967	5.45	5.10	1.97	4.96	5.00	2.26	5.82	4.54	2.67	3.63	0.83	11.51	53.74	4.48	11.51	0.83
1968	3.27	2.19	4.59	3.38	1.85	5.79	5.32	3.69	4.32	3.53	5.24	7.77	50.94	4.25	7.77	1.85
1969	3.51	3.87	6.76	5.77	4.16	0.66	9.58	9.32	3.04	2.19	1.50	4.49	54.85	4.57	9.58	0.66
1970	2.92	4.02	6.52	1.53	3.89	4.51	2.76	7.60	2.00	7.56	2.24	6.37	51.92	4.33	7.60	1.53
1971	2.67	7.58	3.96	1.12	3.05	4.56	4.80	7.11	9.65	2.76	3.11	9.23	59.60	4.97	9.65	1.12
1972	7.59	4.34	6.06	1.84	13.73	3.23	6.14	5.17	2.70	1.84	6.17	10.31	69.12	5.76	13.73	1.84
1973	2.68	4.35	9.27	9.18	5.21	3.52	5.42	7.71	10.80	3.81	5.81	10.10	77.86	6.49	10.80	2.68
1974	8.04	4.25	7.66	9.99	5.42	3.02	3.18	4.50	7.31	0.98	5.91	3.95	64.21	5.35	9.99	0.98
1975	6.40	1.57	9.57	8.39	6.11	7.44	9.68	7.46	6.49	5.12	2.38	2.93	73.54	6.13	9.68	1.57
1976	2.77	4.89	4.39	1.98	4.10	3.73	7.26	4.61	3.30	5.69	5.89	5.21	53.82	4.49	7.26	1.98
1977	6.28	3.16	7.81	5.32	2.98	1.31	8.06	8.11	8.40	2.89	5.15	3.34	62.81	5.23	8.40	1.31
1978	7.69	2.51	2.73	4.23	7.42	9.45	5.83	6.50	3.99	0.00	4.25	4.03	58.63	4.89	9.45	0.00
1979	6.12	9.62	3.71	13.75	7.21	0.78	11.14	4.62	5.55	1.58	4.89	4.28	73.25	6.10	13.75	0.78
1980	4.28	2.73	13.79	14.18	15.06	2.51	5.41	1.14	3.64	6.71	3.72	0.79	73.96	6.16	15.06	0.79
1981	0.86	12.87	5.15	1.88	2.36	3.91	6.20	3.46	2.57	3.17	2.13	4.96	49.52	4.13	12.87	0.86
1982	3.96	9.16	6.05	4.03	1.17	4.51	9.08	6.87	2.52	3.72	3.77	7.71	62.55	5.21	9.16	1.17
1983	5.85	9.29	11.34	12.48	5.10	6.57	1.70	4.42	5.63	1.63	5.60	7.93	77.54	6.46	12.48	1.63
1984	4.38	7.55	4.12	3.06	6.80	4.43	6.37	8.55	2.01	5.33	4.65	4.54	61.79	5.15	8.55	2.01
1985	5.40	5.82	5.04	4.37	2.44	2.22	7.73	7.24	4.74	13.37	1.76	4.50	64.63	5.39	13.37	1.76
1986	2.71	2.67	3.43	2.30	7.24	2.54	1.91	4.67	4.89	3.81	9.26	5.25	50.68	4.22	9.26	1.91
1987	7.16	9.41	5.73	1.52	4.94	4.30	3.10	6.80	0.70	0.17	6.09	4.78	54.70	4.56	9.41	0.17
1988	4.41	9.99	9.62	4.05	1.67	1.13	10.46	7.98	7.86	3.26	3.59	5.18	69.20	5.77	10.46	1.13
1989	4.63	2.87	7.66	4.27	6.38	10.77	8.95	3.07	2.61	1.32	8.20	9.22	69.95	5.83	10.77	1.32
Mean	5.08	6.01	6.16	5.05	4.89	4.36	6.28	5.98	4.48	3.44	4.37	6.29	62.39			
Max	10.08	14.32	13.79	14.18	15.06	11.81	11.14	9.32	10.80	13.37	10.74	20.16	97.26			
Min	0.86	1.57	1.97	0.52	1.06	0.66	1.70	1.14	0.70	0.00	0.83	0.79	41.19			
SDEV	1.96	3.32	2.79	3.71	3.13	2.82	2.52	1.94	2.45	2.66	2.26	3.53	11.87			

Table 11. Freeze occurrence data.

Location	°F	Spring Probability Level* 90	50	10	Fall Probability Level* 10	50	90	Freeze Free Period Probability Level** 10	50	90
Water Valley	32	3/24	4/04	4/15	10/18	10/30	11/11	224	208	192
	28	3/10	3/22	4/03	10/27	11/10	11/24	249	232	215
	24	2/03	3/01	3/27	11/01	11/16	12/01	291	259	228
Canton	32	3/12	3/25	4/07	10/14	10/29	11/13	235	217	199
	28	2/20	3/08	3/23	10/25	11/10	11/26	271	247	223
	24	1/21	2/17	3/16	11/02	11/25	12/18	311	280	250
Hattiesburg	32	3/01	3/17	4/03	10/24	11/08	11/23	256	235	215
	28	2/04	2/27	3/22	11/02	11/23	12/14	297	268	239
	24	1/06	2/05	3/06	11/10	12/07	1/05	365	303	271

*Probability of temperature as cold or colder, later in the spring or earlier in the fall, than the indicated date

**Probability of longer than indicated period (days)

Table 12. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, January.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	196	196	239	256	85	153	51	298	332	306	[illegible]	120	241	170	281	299	179	36	325	319	133	116	295	104	111	244	196	332	17
2	187	187	273	128	68	341	111	170	213	323	170	68	45	247	17	50	299	341	260	325	70	75	173	123	294	313	187	341	17
3	159	159	273	281	239	162	34	85	332	128	85	51	25	26	197	69	366	295	43	290	113	52	306	42	286	26	159	366	25
4	224	224	196	426	68	341	170	315	349	111	51	332	70	280	277	62	276	225	133	325	334	140	218	116	287	281	224	426	51
5	198	198	68	315	9	358	60	341	145	128	255	17	78	289	204	188	173	50	304	240	266	312	309	182	146	315	198	358	9
6	201	201	128	324	273	170	68	196	162	238	272	153	32	299	127	42	283	37	289	49	229	210	308	312	333	239	201	333	32
7	209	209	298	196	367	230	324	290	366	77	289	26	239	68	17	296	152	47	62	330	78	503	312	141	168	209	209	503	17
8	225	225	119	341	383	332	204	187	349	119	238	77	56	214	281	114	142	201	124	323	309	109	309	318	255	288	225	383	56
9	95	193	153	119	383	128	34	290	357	119	111	119	69	171	280	51	353	286	317	314	330	48	88	298	263	50	193	383	34
10	545	210	383	145	204	256	60	256	196	77	128	128	42	86	281	358	348	110	112	321	308	76	134	291	130	281	210	545	42
11	380	223	68	426	324	383	85	341	77	136	298	170	65	265	43	332	71	174	213	198	350	246	273	110	232	321	223	426	43
12	460	195	153	426	170	341	51	222	94	128	298	264	170	90	68	200	58	76	119	352	94	312	289	74	331	29	195	460	29
13	475	224	273	409	247	60	170	298	332	85	187	323	98	352	102	128	128	66	186	329	166	316	245	172	322	143	224	475	60
14	195	243	409	417	85	119	170	332	289	153	323	187	26	301	349	102	195	302	324	316	304	319	208	225	340	78	243	417	26
15	495	298	366	238	213	426	324	281	281	340	340	417	153	309	349	345	228	317	101	352	345	315	131	308	329	136	298	495	101
16	485	254	77	426	341	366	315	179	264	298	340	323	131	250	179	366	43	80	96	357	191	322	153	335	307	114	254	485	43
17	480	230	409	426	315	34	341	68	119	281	340	247	104	116	357	300	150	92	79	348	341	333	236	36	161	44	230	480	34
18	105	179	230	468	136	85	332	85	77	153	230	85	247	66	357	334	85	95	231	358	60	323	77	76	150	27	179	468	27
19	125	241	136	426	230	298	298	204	136	400	204	331	151	33	306	270	99	62	334	230	290	299	356	327	114	304	241	426	33
20	120	206	417	255	196	119	298	119	102	374	187	221	164	338	196	379	159	61	99	50	84	176	200	355	353	133	206	417	50
21	210	228	298	426	128	213	307	111	332	102	68	221	317	290	366	366	347	183	47	113	51	45	362	356	349	88	228	426	45
22	115	204	43	119	119	273	170	128	247	111	187	366	265	209	298	256	291	322	33	73	109	56	355	373	312	279	204	373	33
23	155	238	238	213	426	196	34	256	323	255	204	408	91	298	247	86	276	69	362	344	336	66	39	354	325	353	238	426	34
24	115	222	222	375	111	256	409	341	349	34	213	349	36	46	51	152	74	390	354	359	356	143	78	227	366	154	222	409	34
25	320	228	228	409	85	162	341	315	306	162	366	94	57	315	26	386	43	186	171	290	267	289	208	355	282	43	228	409	26
26	265	255	255	358	383	94	341	145	323	357	323	26	212	326	63	348	398	50	55	115	373	304	325	367	261	307	255	398	26
27	95	253	253	434	383	50	256	85	340	391	238	306	320	321	322	284	294	113	108	281	366	76	324	68	278	339	253	434	50
28	530	265	460	426	239	300	204	85	153	357	77	17	302	212	318	355	395	358	81	374	302	152	135	35	392	354	265	530	17
29	415	269	366	272	486	320	298	119	281	136	26	451	221	226	322	398	397	244	78	339	145	85	369	174	362	185	269	486	26
30	460	246	324	383	426	298	60	43	426	221	111	315	332	304	340	87	83	93	50	82	131	208	383	281	318	386	246	460	43
31	420	240	119	434	128	204	136	68	383	298	340	128	332	185	77	458	[illegible]	389	115	137	131	205	379	60	376	359	240	458	60
TOTAL	8659	6943	7474	10297	7190	7068	6056	6253	8035	6398	6516	6400	4691	6702	6758	7460	6515	5350	5205	8233	6962	6231	7577	6595	8533	6422	6943	13328	1140

Table 13 Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, February

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	MAX	MEAN
1	435	281	477	122	341	196	111	85	43	402	94	281	105	47	552	551	4	165	415	50	382	220	573	37	533	143	535	477	37
2	415	42	452	462	347	62	426	196	53	196	51	477	355	44	266	536	256	153	296	471	113	62	461	73	80	122	530	470	42
3	440	538	426	486	503	77	341	403	451	470	566	494	119	32	552	131	403	90	153	400	61	46	297	574	169	139	593	538	32
4	125	319	332	469	511	341	383	375	400	400	323	281	340	191	293	386	385	219	332	385	78	331	393	259	213	211	505	511	8
5	135	462	230	273	452	366	352	213	179	417	357	298	289	287	72	402	254	111	82	142	115	191	343	285	100	202	556	462	72
6	555	412	383	128	113	85	409	341	221	426	63	374	136	56	34	417	366	45	402	334	251	33	376	101	463	1	550	555	33
7	485	109	358	128	281	460	443	213	366	215	247	136	85	383	553	412	349	88	356	69	317	86	101	58	1	63	505	515	69
8	140	143	571	153	332	452	450	307	113	460	349	145	113	326	375	321	310	256	43	417	51	19	94	341	109	405	75	511	43
9	245	462	400	264	85	383	409	145	366	468	351	137	357	287	366	421	243	400	51	326	1	535	535	402	83	421	545	478	51
10	510	202	400	332	256	356	400	315	391	426	255	596	383	109	245	389	413	440	137	1	211	53	93	221	103	403	509	528	53
11	455	286	562	196	463	111	494	358	400	270	238	570	334	141	14	73	427	197	201	447	397	66	165	152	51	245	591	570	50
12	520	546	496	332	68	409	426	426	434	77	315	383	387	75	201	204	225	157	356	402	146	137	273	69	260	348	297	545	68
13	470	496	477	349	426	426	341	400	264	366	400	60	97	385	224	441	231	135	406	341	308	275	57	445	421	379	332	496	57
14	460	580	537	588	324	341	256	111	170	426	323	102	106	406	256	523	180	277	218	249	397	413	365	429	404	347	350	588	102
15	95	563	375	511	77	213	136	51	43	68	238	332	24	230	231	415	211	273	152	132	197	424	417	437	152	46	234	563	24
16	510	563	460	247	170	170	85	113	145	357	170	511	271	114	135	372	410	114	91	109	274	415	418	456	429	54	278	563	54
17	280	529	153	281	426	85	375	162	434	247	477	426	422	336	225	431	269	72	475	220	219	227	426	421	162	96	305	529	72
18	135	92	426	571	341	128	400	426	383	366	462	417	134	135	387	444	337	218	437	141	251	457	434	403	276	152	318	571	92
19	625	529	503	596	494	213	341	392	503	119	477	511	573	296	409	331	489	469	124	388	454	427	590	375	476	227	402	625	119
20	390	512	349	562	400	170	392	273	425	400	204	570	435	424	290	475	441	65	442	457	396	423	285	135	324	53	360	570	53
21	210	235	630	400	503	486	85	230	460	94	323	340	55	475	254	457	226	273	302	201	476	427	168	389	404	83	313	630	55
22	275	537	562	622	315	239	324	119	264	451	43	306	274	122	336	520	496	101	344	331	473	340	391	510	114	97	308	622	43
23	210	327	562	579	170	469	375	315	255	502	213	502	470	96	433	87	498	102	373	486	424	110	356	579	237	375	535	579	87
24	495	655	571	153	145	486	460	383	85	443	247	366	387	430	425	264	507	94	435	480	322	316	454	150	467	273	364	655	85
25	215	356	503	707	511	435	366	392	289	323	289	485	459	444	249	453	145	169	442	427	59	245	429	184	470	232	357	707	59
26	365	584	256	579	213	195	383	400	502	315	247	94	457	272	423	305	478	470	498	466	42	436	460	72	451	29	342	584	29
27	340	449	85	562	154	68	511	426	402	468	357	127	444	446	424	459	374	474	477	386	86	451	255	174	323	97	340	562	68
28	95	271	622	204	143	494	77	511	213	460	391	323	376	278	573	445	151	305	475	178	251	225	47	305	397	347	306	622	47
TOTAL	9630	11080	12148	10920	8476	7933	9601	8093	8400	9066	7947	9694	7716	6752	8110	9781	8896	6249	8552	8487	6890	7533	9214	7525	7988	6178	8574	15705	1674

Table 14. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, March.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	175	169	205	256	511	477	511	264	383	298	255	332	346	411	276	483	157	400	135	98	490	90	421	417	271	257	311	511	90
2	575	593	358	170	341	460	307	452	263	225	68	306	298	434	281	263	90	245	525	473	398	432	478	102	482	486	350	593	68
3	210	576	562	213	230	239	630	298	68	434	357	511	257	182	232	39	109	173	524	200	250	101	314	318	420	460	304	630	39
4	300	330	426	341	469	341	511	494	221	485	43	349	334	277	298	511	411	350	103	175	227	391	117	407	420	499	340	511	43
5	385	102	665	204	469	170	426	239	289	306	545	502	239	475	201	264	541	547	443	128	388	222	148	76	496	476	344	665	76
6	635	610	435	375	613	85	426	85	502	289	528	247	274	166	375	413	273	529	507	366	67	351	74	483	494	449	371	635	67
7	440	610	119	247	554	511	469	486	94	553	330	374	419	376	295	540	273	400	143	270	389	482	328	502	516	181	381	610	94
8	55	474	256	622	222	460	417	469	383	536	451	494	475	488	36	519	83	512	218	489	530	523	517	743	470	88	405	743	36
9	395	542	136	520	554	366	68	571	528	374	468	358	373	149	117	334	69	519	451	521	358	484	506	294	494	453	385	571	68
10	295	635	758	469	511	273	375	571	298	519	460	136	390	190	463	368	517	96	522	490	481	167	503	366	499	182	405	758	96
11	360	246	562	213	426	383	68	562	77	213	400	553	68	114	301	163	399	565	174	528	244	184	109	442	365	200	305	565	68
12	630	375	707	230	426	460	60	358	111	306	434	536	503	167	219	487	348	563	246	415	194	539	385	266	322	452	375	707	60
13	660	352	400	352	298	426	579	545	553	230	255	238	175	44	104	528	145	252	460	501	165	554	295	463	53	524	352	660	44
14	245	383	239	383	170	375	426	290	562	213	460	51	471	512	369	544	468	591	527	211	304	514	379	411	325	529	383	591	51
15	510	348	792	348	213	341	213	85	587	587	366	34	370	182	76	455	490	388	367	211	202	503	504	131	472	272	348	792	34
16	695	410	750	410	469	511	545	213	520	502	170	102	524	174	348	484	525	216	72	564	273	503	412	502	339	415	410	750	72
17	565	389	682	389	486	494	383	341	306	570	255	638	506	265	509	250	588	514	86	578	277	127	164	402	306	44	389	682	44
18	485	382	511	382	213	494	426	230	357	230	562	579	172	262	454	316	576	356	586	130	383	176	162	563	445	510	382	586	130
19	205	418	665	418	469	469	460	528	213	536	545	281	307	526	252	205	577	473	86	577	463	527	396	560	185	515	418	665	86
20	180	737	545	741	469	128	281	469	315	579	434	187	132	517	330	421	513	398	87	555	282	516	129	552	375	525	400	741	87
21	665	754	281	716	460	486	85	596	111	162	272	664	181	408	527	267	283	149	587	138	89	74	291	82	561	528	362	754	74
22	210	703	741	596	460	554	426	477	613	306	570	655	556	410	532	614	610	182	581	115	493	308	541	185	590	446	480	741	115
23	620	695	562	239	452	511	630	85	604	332	434	621	335	278	528	594	555	229	132	576	504	566	548	122	584	276	447	695	85
24	595	558	298	170	494	426	596	315	502	570	340	77	313	533	151	254	180	592	522	558	492	141	427	204	554	573	401	596	77
25	330	623	162	136	494	281	545	511	323	119	281	102	288	547	173	501	154	631	295	479	424	580	351	576	563	547	385	631	102
26	630	713	767	196	222	128	494	656	374	400	272	119	295	485	206	352	193	599	163	537	605	595	548	593	567	467	430	767	119
27	615	724	724	375	622	281	511	596	613	553	298	460	257	275	554	174	599	230	107	461	316	163	422	517	451	474	437	724	107
28	540	615	630	324	281	537	477	554	451	230	409	545	268	87	371	606	608	525	329	502	486	569	166	139	542	582	437	630	87
29	305	615	767	389	571	554	409	170	162	613	519	468	522	29	186	325	554	386	80	79	571	498	99	346	610	288	389	767	29
30	260	559	724	424	630	511	400	341	221	604	417	128	525	529	208	468	611	193	409	582	254	537	538	304	535	100	424	724	100
31	120	607	639	476	554	494	324	341	570	562	604	400	540	402	551	534	606	396	498	561	398	220	594	243	552	602	476	639	120
TOTAL	12890	15847	16068	11324	13353	12226	12478	12192	11174	12436	11802	11047	10713	9894	9523	12276	12105	12199	9965	12068	10997	11637	10866	11317	13858	12400	12026	20634	2368

Table 15. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, April.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	640	681	469	464	511	554	460	562	153	102	570	621	256	426	555	132	628	345	548	628	392	458	276	543	500	595	464	681	102
2	675	623	239	426	596	596	153	383	604	613	570	519	589	300	576	183	579	234	355	619	166	113	582	607	484	206	446	675	113
3	660	399	315	341	298	545	196	545	596	587	477	332	447	604	544	63	535	141	215	320	617	78	87	627	449	359	399	660	63
4	380	440	477	520	596	554	170	341	553	604	289	306	276	582	505	190	258	439	619	123	337	613	504	605	537	623	440	623	123
5	115	220	119	383	622	596	562	256	528	468	460	629	601	462	380	649	618	661	626	634	389	370	365	583	317	618	470	661	115
6	180	119	801	256	596	511	639	273	604	374	298	315	606	582	585	633	576	633	407	646	630	64	621	310	323	434	462	801	64
7	335	762	562	358	554	537	196	588	613	621	315	204	171	233	573	623	615	547	319	342	438	83	632	397	441	533	446	762	83
8	425	313	718	511	383	554	129	562	502	587	340	587	371	70	521	627	510	193	635	231	213	97	226	599	505	492	419	718	70
9	675	407	809	596	707	639	170	375	170	528	621	494	606	309	602	621	423	574	648	297	416	83	140	648	123	609	473	809	83
10	345	398	489	489	639	298	545	562	468	511	519	706	523	362	545	630	150	361	639	526	233	495	410	646	647	577	489	706	150
11	220	356	461	543	400	204	613	630	213	570	400	655	421	575	546	634	431	184	128	451	660	598	313	616	559	607	461	660	128
12	660	745	450	622	332	460	554	341	383	553	485	630	75	609	335	626	248	157	93	407	653	647	588	185	473	386	450	745	75
13	685	703	419	682	469	426	239	222	604	536	553	392	276	101	156	584	666	576	65	573	148	576	319	422	358	136	419	703	65
14	505	678	501	392	469	392	460	469	638	638	366	570	521	156	526	609	587	689	348	515	395	514	668	460	571	383	501	689	166
15	710	661	767	546	665	554	682	613	417	519	383	187	545	533	555	594	672	675	652	606	283	624	582	378	275	272	537	767	187
16	695	542	716	767	656	366	682	537	238	562	638	568	589	598	393	571	584	679	652	421	405	690	470	526	654	568	568	767	238
17	135	364	554	767	665	298	196	145	264	434	587	459	632	324	490	560	399	596	287	424	412	674	414	627	648	588	459	767	135
18	610	593	545	456	341	494	511	256	462	323	553	456	592	387	436	167	648	415	413	404	455	589	76	636	418	613	456	648	76
19	625	305	170	478	469	630	511	324	340	579	443	478	595	593	520	397	599	485	648	494	137	222	633	539	595	618	478	648	137
20	560	435	579	707	341	537	494	383	562	365	332	435	567	510	211	113	699	242	665	479	80	249	76	592	376	628	435	707	76
21	610	463	494	707	170	392	213	596	570	638	111	463	321	641	491	126	697	183	655	546	329	641	535	585	241	620	463	707	111
22	590	678	289	682	426	554	170	648	323	400	672	459	184	464	623	463	697	129	636	304	429	452	260	335	603	467	459	697	129
23	515	254	588	682	281	257	469	639	374	596	638	491	517	272	586	541	607	302	642	141	684	116	632	530	671	649	491	684	116
24	432	347	85	478	315	648	716	656	383	672	587	85	639	567	245	549	351	503	580	557	431	146	677	365	667	650	478	716	85
25	671	246	511	509	162	170	639	665	196	553	638	392	636	385	573	691	638	518	158	553	478	619	682	631	648	660	509	691	158
26	741	576	239	531	417	460	596	724	145	596	545	264	628	425	607	694	724	293	172	672	463	714	682	616	650	653	532	741	145
27	325	246	682	383	648	434	511	511	315	349	391	638	609	534	650	691	722	663	391	652	580	706	248	306	665	635	519	722	246
28	624	424	767	767	569	562	613	665	400	655	383	689	612	190	585	649	697	726	632	601	626	537	339	332	475	668	563	767	190
29	685	457	852	801	281	511	554	682	604	204	570	689	637	126	96	659	366	314	681	612	417	459	152	459	691	667	509	852	96
30	445	779	665	767	366	469	565	682	640	255	477	536	483	145	113	680	483	691	387	403	445	377	296	530	595	604	499	779	113
	15473	14214	15332	16611	13944	14202	13308	14835	12868	14993	14211	14249	14625	12175	14123	14949	16407	13148	13896	14281	12341	12604	12491	15235	15159	16118	14300	21553	3638

Table 16. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, May.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	325	788	656	767	205	119	665	494	447	630	298	290	161	508	411	399	467	423	323	412	287	196	692	499	518	650	447	788	119
2	788	796	716	467	341	767	665	596	467	638	153	397	451	202	651	215	605	342	323	706	524	253	193	479	300	99	467	796	99
3	782	593	852	512	639	750	511	639	512	519	604	591	525	228	645	443	109	334	600	584	629	489	282	124	492	318	512	852	109
4	770	703	826	622	639	298	630	417	630	621	664	597	280	586	653	388	243	223	601	404	647	561	598	636	683	571	557	826	223
5	780	703	681	724	648	247	682	443	681	264	630	575	239	515	675	633	597	161	658	221	565	725	621	697	689	474	559	780	161
6	761	847	639	579	503	341	724	383	638	213	587	253	606	465	355	539	287	624	670	501	350	704	513	593	517	247	517	847	213
7	725	728	494	724	656	682	699	213	596	468	213	232	644	297	172	647	165	647	194	278	169	714	485	389	397	312	459	728	165
8	778	737	511	682	630	716	324	230	655	672	391	592	449	541	643	599	444	642	415	595	718	234	429	579	519	647	553	778	230
9	764	805	315	596	639	682	409	716	553	366	332	580	588	110	635	663	750	660	726	393	716	321	668	362	512	650	558	805	110
10	758	847	673	471	639	588	256	682	357	179	655	581	460	595	346	748	744	540	676	317	671	669	705	217	610	339	551	347	179
11	778	551	357	596	511	682	392	699	485	196	587	418	73	499	547	659	460	506	545	706	689	417	742	340	344	405	507	778	73
12	772	737	374	724	469	545	256	630	553	43	128	371	655	629	522	653	420	147	222	708	662	251	704	387	341	476	476	772	43
13	766	695	852	707	349	596	485	596	630	698	587	598	665	612	180	664	760	750	294	680	522	642	653	656	689	449	607	852	180
14	727	771	843	426	707	554	426	596	621	681	596	522	529	347	413	498	759	735	452	568	565	583	655	570	639	449	586	843	347
15	764	762	741	724	639	596	349	665	536	672	664	599	142	305	319	584	697	718	163	699	552	334	424	370	604	465	542	764	142
16	758	737	741	588	639	699	545	460	579	672	638	608	564	209	483	607	679	716	304	170	684	751	697	734	300	487	579	758	170
17	748	423	767	426	315	630	111	247	535	672	553	596	515	625	457	500	254	740	601	515	656	468	676	768	595	525	535	768	111
18	756	652	767	537	639	682	307	511	715	587	655	571	487	658	675	653	530	666	652	199	307	736	717	647	204	502	577	767	199
19	774	534	639	409	349	699	767	511	689	511	613	564	589	603	688	551	439	712	168	483	377	257	597	565	276	518	534	774	168
20	762	508	724	341	630	341	767	630	536	545	638	541	549	583	614	532	629	667	604	553	578	734	604	445	329	540	574	767	329
21	773	813	506	630	469	85	298	630	604	681	689	316	217	609	603	524	470	396	266	739	685	261	261	466	549	609	506	813	85
22	642	305	525	525	716	665	656	622	740	579	596	503	176	617	458	673	499	432	391	719	534	420	458	254	579	359	525	740	176
23	532	967	573	573	435	835	724	596	621	400	621	373	644	588	647	588	640	498	556	596	542	496	527	443	454	434	573	967	373
24	724	822	553	741	435	639	665	511	562	374	536	608	610	592	288	421	568	742	651	532	557	510	445	621	471	197	553	822	197
25	625	652	573	682	682	665	630	383	537	689	613	502	475	616	619	647	406	738	496	311	369	752	691	713	385	458	573	752	311
26	618	635	690	630	716	622	639	596	522	581	579	415	328	490	125	550	591	611	662	334	442	729	647	609	264	634	552	729	125
27	590	553	647	579	571	596	716	596	477	213	477	292	668	589	219	645	605	122	640	584	660	590	616	668	260	648	532	716	122
28	612	373	621	341	665	554	682	554	502	672	596	420	635	522	249	675	321	388	588	674	529	617	670	486	353	640	536	682	249
29	385	889	852	716	596	560	656	511	417	681	485	603	495	358	642	703	603	374	582	584	633	589	545	546	486	551	579	889	358
30	182	864	545	818	656	247	554	622	511	621	511	603	500	463	630	701	681	225	562	552	635	547	713	578	611	336	556	864	182
31	696	788	102	682	639	128	638	639	400	604	587	493	132	623	420	633	583	519	511	440	534	724	654	630	624	545	537	788	102
TOTAL	21215	21578	19355	18539	17366	16810	16828	16618	17308	16042	16476	15204	14051	15184	14984	17935	16005	15998	15096	15757	16988	16274	17882	16071	14594	14534	16719	24652	5650

Table 17. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, June.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	644	635	741	665	699	213	596	494	477	417	664	357	253	686	288	741	447	629	676	575	728	222	747	647	178	614	540	747	178
2	474	805	750	724	596	130	469	707	332	519	638	621	617	669	459	736	370	415	676	575	626	697	721	657	481	621	580	805	130
3	680	687	792	750	648	450	545	656	596	511	613	562	594	660	473	694	431	210	644	395	564	659	719	694	367	351	575	792	210
4	340	635	716	767	588	665	682	205	485	562	528	340	581	676	498	668	726	592	542	364	574	510	712	726	443	619	567	767	205
5	784	720	733	707	511	383	613	639	477	451	579	349	443	474	203	625	700	328	637	126	648	470	635	719	328	727	541	784	126
6	690	754	528	622	639	554	630	596	579	528	562	621	420	295	609	692	420	629	697	269	688	618	633	575	474	711	578	754	269
7	498	737	613	622	383	511	639	639	613	315	357	638	264	309	671	778	282	601	575	507	644	264	270	451	381	668	509	778	264
8	695	754	681	741	665	409	622	639	672	417	511	447	339	556	582	748	520	673	421	536	667	667	419	501	505	598	580	754	339
9	396	779	639	511	639	596	622	511	553	587	485	332	546	293	516	734	771	690	473	537	602	743	713	684	391	503	571	779	293
10	480	788	656	511	716	622	639	630	468	536	579	409	559	138	571	699	767	682	773	441	469	738	621	636	324	376	570	788	138
11	672	796	656	358	682	596	511	622	655	553	613	443	657	362	587	722	711	794	679	464	626	697	558	555	438	635	602	796	358
12	544	669	656	554	630	511	665	469	426	638	638	545	486	688	597	562	482	768	732	436	278	466	596	420	402	229	542	768	229
13	644	779	715	588	315	511	682	571	443	638	596	349	629	692	665	360	750	712	728	635	644	620	664	659	699	252	598	779	252
14	832	584	733	469	545	554	699	596	536	647	494	417	660	232	611	236	785	640	707	663	593	620	384	732	709	583	587	832	232
15	788	695	665	664	571	623	665	366	629	519	145	485	402	528	454	342	767	651	718	626	687	551	623	756	692	536	586	788	145
16	764	254	298	707	511	545	503	639	570	604	374	502	630	612	181	494	646	670	691	556	167	340	605	670	640	518	527	764	167
17	798	381	596	682	571	494	630	639	604	630	504	545	580	564	293	476	669	728	547	609	582	543	433	524	625	389	567	798	293
18	766	695	648	741	443	511	426	554	638	681	621	604	320	630	173	654	514	697	649	607	691	364	661	660	681	529	586	766	173
19	524	618	673	758	648	515	239	383	613	494	664	528	653	570	232	635	433	515	304	621	443	305	562	208	716	499	514	758	208
20	812	457	724	784	656	600	545	239	579	621	655	553	648	634	629	631	604	728	248	619	683	627	690	596	694	433	603	812	239
21	562	237	699	741	556	630	383	537	443	451	681	357	606	442	571	653	462	266	543	702	331	693	513	727	637	615	548	741	237
22	774	728	665	707	571	620	392	613	528	587	511	460	606	521	493	742	438	403	675	645	550	595	637	552	589	630	586	774	392
23	782	754	452	537	443	640	426	426	630	596	587	604	561	610	467	706	654	643	490	620	578	333	667	486	543	613	571	782	333
24	685	745	758	648	656	450	469	571	221	536	374	596	586	558	519	635	662	233	207	641	499	394	593	679	613	465	544	758	207
25	654	644	843	477	528	650	588	665	502	485	255	596	663	644	542	531	715	532	563	242	583	448	634	661	488	619	568	843	242
26	680	542	716	561	520	622	426	511	570	485	238	621	554	617	454	601	721	659	561	692	340	390	737	601	563	604	561	737	238
27	770	381	707	577	451	545	724	486	715	391	383	357	646	538	448	678	622	723	709	722	432	355	737	579	612	719	577	770	355
28	542	618	733	586	392	596	716	613	732	502	528	579	663	582	573	678	541	688	661	590	358	500	497	593	390	684	586	733	358
29	388	508	494	682	409	639	639	579	621	434	374	579	595	311	632	581	550	658	572	522	516	544	565	775	365	700	547	775	311
30	742	745	630	707	579	511	665	460	630	511	596	460	636	611	455	626	569	677	673	433	461	620	353	774	612	422	583	774	353
TOTAL	19511	19124	19910	19148	16861	15896	17050	16255	16537	15846	15447	14856	16397	15672	14551	13778	17829	17838	17781	16170	16252	15593	17899	18497	15581	16560	16994	23296	7474

Table 18. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, July.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	610	559	514	562	315	383	682	664	562	434	511	477	558	589	512	576	644	537	649	211	609	584	153	675	459	338	514	682	153
2	807	737	548	596	256	426	460	443	596	408	536	477	652	462	484	577	659	719	685	275	626	709	613	336	593	566	548	807	256
3	748	745	567	767	545	596	341	588	613	664	417	528	609	609	454	667	527	707	644	524	688	555	633	363	250	440	569	767	250
4	790	669	673	571	596	460	716	571	528	494	357	477	469	567	111	635	730	719	705	478	669	368	565	467	566	306	548	790	111
5	794	711	690	767	545	395	682	502	596	681	723	528	464	536	597	673	692	591	646	241	539	587	672	643	677	626	608	794	241
6	768	720	665	665	596	153	426	630	638	528	723	340	516	605	633	670	714	483	658	565	583	456	489	596	660	419	573	768	153
7	774	711	682	707	554	469	460	613	604	621	681	179	555	602	578	677	621	410	661	569	484	716	601	585	511	518	582	774	179
8	780	432	724	724	588	545	400	639	238	596	630	315	460	573	577	539	662	332	686	663	485	754	578	689	646	492	567	780	238
9	765	779	486	724	588	341	588	553	587	434	528	604	535	624	592	541	670	574	618	492	467	404	682	679	602	335	569	779	335
10	742	711	477	682	409	545	639	528	578	604	621	613	627	371	604	572	700	560	702	664	615	569	202	694	664	541	586	742	202
11	650	728	400	682	511	622	435	451	485	579	638	553	633	621	588	452	595	170	687	605	441	612	703	663	646	615	568	728	170
12	738	532	588	724	528	273	494	596	596	528	596	664	433	614	551	620	624	671	692	663	599	545	644	679	746	669	600	746	273
13	737	407	835	665	579	341	545	545	655	562	528	579	443	634	593	610	678	556	696	687	582	528	647	665	624	638	598	835	341
14	755	364	716	630	613	724	460	570	502	604	587	570	608	643	429	695	475	595	689	554	654	493	442	636	655	526	584	755	364
15	739	580	613	554	579	596	554	587	579	579	485	374	512	551	597	645	495	523	681	518	578	610	625	617	622	689	580	739	374
16	539	573	724	639	341	409	511	596	443	570	511	366	551	603	442	708	738	637	684	655	549	590	663	614	561	687	573	738	341
17	727	566	750	733	562	511	639	528	366	460	596	366	577	606	631	676	716	573	668	654	554	279	406	355	613	615	566	750	279
18	803	577	699	707	554	511	528	238	596	621	519	553	332	589	662	654	703	642	679	602	489	542	362	585	621	629	577	803	238
19	802	563	733	622	426	298	426	247	553	630	587	511	607	604	578	442	624	379	689	653	623	587	669	687	494	601	563	802	247
20	728	568	741	588	239	426	537	647	460	349	604	596	498	554	591	622	683	451	549	668	475	572	726	623	640	636	568	741	239
21	519	559	711	673	511	596	511	536	127	596	613	587	559	583	553	614	626	519	330	552	629	552	714	553	654	545	559	714	127
22	745	390	677	639	596	545	239	485	94	613	621	579	577	344	615	502	671	645	323	620	590	627	581	443	593	299	525	745	94
23	701	390	545	639	443	486	383	366	332	315	511	536	131	584	607	511	647	536	484	590	602	457	618	203	522	377	481	701	131
24	616	610	677	639	409	460	511	596	536	187	545	553	306	402	611	500	615	485	652	628	395	670	575	417	647	517	529	677	187
25	339	525	579	724	554	630	605	221	349	153	596	460	564	380	631	357	624	479	643	640	380	631	584	418	613	366	502	724	153
26	416	440	463	511	503	460	630	60	426	340	570	357	288	364	435	444	683	480	612	600	467	663	643	627	594	643	489	683	60
27	484	644	724	596	562	630	579	485	519	289	494	528	561	387	552	482	553	491	287	646	493	396	622	448	611	611	526	724	287
28	466	661	588	545	554	537	639	613	570	323	553	596	593	586	573	399	705	416	586	569	494	408	269	665	537	630	541	705	269
29	495	669	494	682	503	469	426	571	596	408	400	340	602	546	587	235	678	653	673	312	538	590	447	689	629	510	529	689	235
30	717	508	417	741	366	630	392	596	587	204	426	315	515	232	556	414	699	691	683	646	318	539	653	684	654	529	527	741	204
31	762	542	622	624	545	511	545	511	570	587	468	238	315	200	480	500	485	586	634	674	359	580	636	600	641	599	531	762	200
TOTAL	21056	18170	19322	20322	15470	14978	15983	15776	15481	14961	17175	14759	15650	16165	17004	17209	19936	16810	19275	17418	16574	17173	17417	17598	18545	16512	17180	23185	6931

Table 19. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, August.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	562	504	400	580	579	383	562	613	562	408	502	409	492	183	475	349	623	425	509	634	240	618	614	646	638	602	504	646	183
2	421	513	682	767	119	256	596	588	460	281	630	528	505	346	526	691	598	228	663	627	486	559	504	571	593	602	513	767	119
3	310	523	733	682	204	469	545	664	536	315	604	587	515	483	645	712	673	448	582	557	540	323	341	737	255	609	523	737	204
4	736	570	707	565	443	477	579	639	570	383	562	570	628	377	526	648	576	568	644	605	488	512	420	734	612	591	570	736	377
5	754	627	375	741	443	460	554	622	408	289	613	545	647	456	543	665	580	675	618	606	569	432	179	580	629	481	542	754	179
6	721	593	588	716	588	588	596	596	442	502	596	383	543	554	547	665	674	633	661	628	319	541	558	481	636	581	577	721	319
7	759	551	630	519	469	554	400	605	434	562	511	460	365	297	565	668	617	647	570	356	499	662	506	174	505	602	519	759	174
8	787	635	630	777	511	545	586	613	213	383	604	536	447	506	642	677	287	607	601	656	574	540	372	444	522	595	550	787	213
9	775	644	571	682	469	503	494	613	426	408	553	553	438	500	630	678	537	608	601	656	502	569	494	630	304	606	556	775	304
10	713	559	588	665	477	196	469	639	264	323	391	536	560	577	632	617	358	623	606	643	546	669	500	634	559	265	523	713	196
11	710	559	426	648	230	545	341	630	366	528	426	545	428	481	603	532	637	460	439	565	508	629	213	562	491	290	492	710	213
12	706	551	400	366	375	673	443	596	374	587	443	511	527	524	550	508	577	510	591	595	426	718	513	553	570	514	527	718	366
13	778	466	554	750	511	665	332	553	462	545	553	494	403	418	547	577	383	600	569	584	451	318	412	604	662	513	527	778	318
14	770	457	366	746	562	554	443	605	477	511	596	392	581	526	589	585	641	655	587	585	324	379	360	577	637	352	533	770	324
15	722	805	392	751	537	511	460	553	502	494	570	562	433	522	494	582	551	668	636	542	371	639	400	468	512	555	547	805	371
16	710	762	532	741	460	545	579	511	477	613	454	570	310	345	589	658	655	473	623	433	475	562	382	239	516	607	532	762	239
17	773	703	519	611	511	469	537	588	613	494	451	323	477	426	551	344	665	666	620	334	401	426	550	519	401	528	519	773	323
18	732	686	443	594	528	366	630	145	528	391	536	315	539	149	551	212	652	636	636	340	499	567	496	519	563	362	485	732	145
19	709	508	665	576	443	383	571	485	596	485	502	468	477	425	528	624	631	510	639	289	560	637	568	579	629	575	541	709	289
20	682	517	571	686	375	469	298	528	519	519	570	536	594	526	554	653	632	619	648	300	485	591	200	461	567	536	524	686	200
21	718	517	417	614	494	392	545	426	383	485	579	587	571	514	545	528	642	605	639	415	526	491	514	470	575	599	530	718	383
22	672	695	417	501	452	452	554	324	408	357	536	587	497	571	428	527	651	336	654	346	540	514	538	478	459	533	501	695	324
23	535	644	460	469	588	426	596	153	255	281	527	570	536	597	520	492	635	637	667	591	532	612	350	613	599	552	517	667	153
24	443	601	452	426	545	494	562	502	426	494	502	536	538	464	477	463	594	433	558	459	581	590	571	561	688	572	521	688	426
25	392	618	375	639	596	383	571	451	553	426	519	502	460	592	533	485	577	396	639	531	576	720	632	416	510	549	525	720	375
26	672	567	520	596	545	281	639	485	587	502	511	510	306	486	476	457	525	507	497	449	570	755	557	555	547	506	523	755	281
27	722	491	554	639	409	358	596	375	528	511	579	519	517	426	420	473	606	445	521	330	473	575	506	583	494	383	501	722	330
28	726	483	648	515	400	494	630	545	443	613	570	494	366	431	309	568	275	598	345	370	376	782	570	510	324	381	491	782	275
29	271	466	605	704	526	596	486	519	519	545	511	162	256	541	439	501	174	622	416	607	483	542	331	592	551	534	481	704	162
30	535	313	596	750	520	596	579	588	502	408	519	511	116	347	477	524	260	538	619	595	378	572	545	553	622	283	494	750	116
31	708	508	588	716	315	341	366	324	528	417	477	553	91	449	395	596	582	571	599	227	436	618	371	573	537	315	469	716	91
TOTAL	20224	17636	16404	19832	14224	14424	16139	16078	14367	14060	16497	15354	14163	14039	16306	17259	17068	16947	18197	15465	14734	17662	14067	16616	16767	15573	16157	22755	7972

Table 20. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, September.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	642	739	528	341	425	596	545	307	570	264	468	323	137	555	370	604	377	448	594	243	534	202	461	553	507	603	459	739	137
2	664	686	639	596	392	486	332	332	426	374	528	85	250	539	268	605	351	532	579	434	479	544	466	575	393	607	468	686	85
3	714	610	639	410	443	332	111	281	383	502	357	315	177	512	98	585	366	580	576	162	506	485	474	269	195	577	410	714	98
4	487	424	571	393	298	119	298	392	502	315	196	417	574	513	266	516	598	584	575	515	598	461	354	233	449	558	433	598	119
5	395	491	545	595	494	298	341	460	511	247	443	102	539	357	480	485	585	506	504	584	579	456	554	176	398	511	448	595	102
6	479	601	554	554	537	196	596	400	553	434	477	119	161	216	510	333	538	538	537	551	465	480	604	481	333	473	451	604	119
7	479	186	486	511	443	111	511	417	519	502	400	221	336	533	317	533	551	551	557	585	551	362	582	541	284	466	444	585	111
8	211	695	571	469	477	477	571	485	536	468	502	451	128	489	332	469	479	633	445	397	528	532	570	543	499	406	476	695	128
9	264	593	554	648	400	503	409	468	562	553	468	494	439	468	409	174	418	614	541	580	524	503	538	500	544	433	485	648	174
10	360	601	579	85	213	520	571	536	451	323	528	477	407	497	457	506	534	535	552	593	366	534	233	484	501	333	453	601	85
11	479	525	613	102	196	383	486	502	528	417	426	460	463	385	581	572	258	578	565	585	307	551	518	513	455	223	449	613	102
12	604	508	622	656	383	315	554	545	485	545	400	426	302	140	553	517	194	511	541	536	192	443	478	368	395	422	448	656	140
13	588	271	656	596	460	400	554	511	494	511	417	332	106	475	528	298	162	146	513	345	448	182	551	526	547	486	427	656	106
14	312	161	596	554	366	341	463	434	553	468	477	477	176	454	460	328	244	601	520	226	476	452	527	541	572	453	432	601	161
15	178	169	605	554	187	341	77	460	511	443	460	298	486	380	482	215	274	604	542	352	476	566	545	176	536	394	397	605	77
16	298	271	417	596	204	477	341	468	468	119	225	349	495	122	512	424	504	560	473	517	400	580	618	432	370	366	408	618	119
17	496	189	213	596	452	537	204	417	485	485	272	477	216	363	278	352	461	130	333	517	468	492	615	526	312	476	399	615	130
18	680	369	562	580	239	511	503	485	511	451	426	536	483	483	426	502	486	203	476	591	478	539	554	532	433	142	469	680	142
19	655	626	545	616	494	452	497	358	408	85	408	417	479	451	423	223	508	161	548	509	492	492	436	543	430	349	446	655	85
20	714	591	562	511	119	375	495	272	485	204	383	366	470	429	222	579	494	49	381	574	311	105	545	499	425	544	412	714	49
21	655	600	511	273	469	333	535	170	426	315	426	451	259	491	502	565	454	137	442	554	494	194	540	524	300	501	428	655	137
22	622	627	501	179	494	503	484	315	494	255	357	477	518	164	519	517	325	531	502	517	540	584	450	420	230	492	447	627	164
23	588	557	426	281	426	545	448	320	196	374	426	383	391	405	508	399	529	555	381	482	538	564	172	489	296	495	430	588	172
24	538	617	630	571	469	528	426	420	213	128	408	349	206	425	492	211	521	573	295	521	321	554	329	318	463	504	424	630	128
25	504	608	579	431	452	460	349	511	238	443	247	426	45	507	379	300	498	529	175	503	450	541	514	568	441	516	431	608	45
26	454	480	494	402	417	460	494	502	281	315	306	417	71	499	371	448	367	502	408	410	182	522	507	278	395	464	402	522	71
27	613	326	290	469	247	128	469	490	230	323	340	255	198	490	235	334	210	407	92	389	493	436	315	513	477	419	353	613	92
28	706	274	294	460	290	435	486	440	554	417	349	247	323	488	128	139	229	510	96	491	481	682	397	547	493	380	398	706	96
29	655	351	162	119	469	554	494	553	502	579	306	323	508	457	216	215	313	439	79	529	481	471	365	514	455	347	404	655	79
30	588	728	272	179	273	469	411	511	511	340	536	357	496	415	469	490	417	491	289	498	366	184	336	438	484	506	425	728	179
TOTAL	15622	14474	15216	13327	11228	12185	13061	12762	13586	11199	11962	10827	9839	12702	11791	12438	12245	13798	13111	14290	13524	13693	14148	13670	12612	13446	12956	19210	3432

Table 21. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, October.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	496	531	412	239	537	452	426	255	460	289	553	349	481	357	426	421	546	509	453	114	475	479	508	79	415	513	416	553	79
2	647	531	449	503	520	383	409	511	426	417	494	315	446	480	474	337	526	556	452	57	397	519	539	472	366	486	450	647	57
3	596	523	432	503	452	417	111	451	468	357	374	281	476	487	446	550	416	520	498	256	414	503	529	494	279	509	435	596	111
4	571	540	443	298	281	426	477	536	528	349	357	400	476	380	409	527	543	515	502	355	435	497	481	443	301	508	445	571	281
5	538	574	409	366	460	426	426	511	451	145	383	374	472	229	167	406	405	544	519	387	415	415	396	409	407	485	412	574	145
6	563	557	553	94	503	392	162	349	170	477	426	272	467	109	454	377	536	495	508	400	171	518	306	376	171	491	321	563	94
7	412	471	519	469	503	409	153	292	162	451	213	272	323	309	316	329	531	514	429	339	121	446	177	351	139	491	356	531	121
8	368	480	562	511	315	256	341	477	315	315	494	281	284	402	96	115	516	496	471	394	138	537	186	363	473	469	372	562	96
9	388	540	613	443	358	318	281	460	468	264	417	281	433	424	465	526	465	144	432	334	279	533	277	479	65	441	390	613	65
10	414	488	605	460	426	545	239	272	528	468	443	332	433	407	461	338	464	487	453	361	257	529	292	464	228	444	415	605	228
11	386	480	596	358	426	460	170	374	238	468	451	289	433	408	450	117	374	489	490	350	324	421	200	467	433	408	387	596	117
12	375	488	468	417	426	469	383	298	213	417	374	247	396	413	427	475	422	484	492	301	60	151	330	453	377	471	379	492	60
13	496	403	358	290	170	443	247	60	323	230	400	68	296	406	419	506	72	474	489	349	435	157	188	375	85	468	315	506	60
14	462	197	77	435	349	460	426	289	272	366	426	43	315	399	374	488	510	502	454	255	455	490	419	292	86	454	357	510	43
15	538	411	281	213	477	426	400	349	196	323	357	77	61	250	338	421	495	459	462	273	440	474	195	236	463	453	349	538	61
16	311	411	545	452	494	128	375	445	451	306	417	94	440	50	83	501	497	308	286	352	448	487	412	126	403	388	354	545	50
17	294	420	511	443	256	85	298	434	400	298	426	400	432	368	434	497	498	363	51	240	331	251	277	299	502	398	354	511	51
18	538	488	443	375	145	469	460	417	213	272	408	400	416	372	429	451	424	403	184	166	432	251	187	368	445	258	364	538	145
19	479	497	272	85	222	469	469	374	128	264	196	332	426	443	291	469	444	432	456	360	414	286	212	253	366	194	342	497	85
20	403	454	528	375	481	460	383	110	196	196	408	357	405	413	301	410	450	328	385	316	297	342	228	242	359	167	345	528	110
21	336	462	369	460	435	426	477	374	230	255	383	366	381	404	420	350	440	326	440	339	327	391	253	187	393	445	372	477	187
22	512	343	322	153	349	409	426	408	366	272	111	374	395	344	341	445	425	156	434	182	412	154	66	265	392	411	326	512	66
23	605	352	330	417	281	400	426	391	162	221	366	392	381	296	236	305	381	479	404	331	424	236	59	153	226	310	329	605	59
24	353	378	268	469	237	292	383	315	315	162	213	392	382	213	57	157	431	439	272	220	423	109	65	80	64	180	265	469	57
25	613	394	307	426	388	460	460	349	400	374	162	323	251	65	74	145	342	445	440	158	415	175	113	350	35	65	297	613	35
26	428	446	332	392	409	383	409	272	485	357	145	315	351	337	239	423	93	433	351	165	400	289	295	302	254	199	327	485	93
27	428	326	320	400	375	469	426	366	102	417	60	306	352	177	287	429	433	433	47	242	397	436	360	178	185	414	324	469	47
28	462	471	295	366	383	400	469	400	68	255	204	298	92	283	330	171	437	219	152	48	349	436	353	64	351	413	299	471	48
29	84	514	284	392	383	341	400	145	443	357	77	357	234	315	72	376	442	262	206	128	99	426	285	78	389	389	288	514	77
30	210	412	284	375	426	132	341	170	417	340	60	239	218	404	87	341	343	262	423	114	316	333	362	83	383	383	288	426	60
31	580	343	298	375	400	341	375	43	434	323	289	102	282	385	206	229	341	203	414	57	300	383	326	51	374	384	301	580	43
TOTAL	13886	13985	12485	11554	11837	11922	11228	10501	13022	10006	10087	9038	11230	10339	9675	11579	13301	12679	12095	7979	10605	11618	8282	8851	9327	12029	11034	16697	2831

Table 22. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, November.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	287	334	417	366	68	170	384	408	366	340	213	340	246	61	386	208	395	435	389	236	150	129	332	66	382	379	290	435	61
2	287	540	332	324	162	383	341	298	434	306	426	315	225	46	372	57	384	425	207	355	93	367	114	85	296	375	290	540	46
3	280	446	349	264	409	68	205	247	426	426	196	153	302	65	355	344	385	415	270	387	110	309	174	84	333	348	283	446	65
4	285	171	272	162	375	443	196	323	281	374	357	85	123	67	368	118	382	426	396	400	393	252	385	300	202	347	288	443	67
5	286	394	255	43	247	400	119	349	426	374	383	43	339	30	368	334	380	392	393	389	391	98	191	398	132	381	290	426	30
6	294	454	298	102	307	426	111	315	434	247	213	289	357	34	340	90	136	381	382	334	373	431	396	396	157	370	297	454	34
7	287	497	247	298	187	409	222	264	374	357	374	136	57	46	343	303	85	392	378	334	370	270	390	386	176	310	288	497	46
8	290	343	392	256	187	383	196	247	366	408	468	77	334	55	370	337	412	251	327	361	341	83	334	380	40	220	287	468	40
9	262	120	358	196	273	358	315	340	366	247	332	306	221	38	314	257	400	46	142	387	308	281	190	384	113	34	253	400	34
10	310	429	426	341	341	324	204	323	408	366	383	349	116	95	263	418	360	257	356	350	325	331	106	269	294	296	309	429	95
11	256	471	366	366	26	128	51	238	315	340	255	315	241	95	60	394	204	365	373	301	216	244	330	237	207	368	260	471	26
12	324	480	324	239	324	375	341	357	162	306	434	298	354	51	382	393	343	382	367	349	220	749	365	213	40	366	325	749	40
13	292	488	426	119	375	315	358	281	179	264	111	247	334	143	255	322	268	389	232	255	374	369	366	310	219	311	292	488	111
14	250	471	298	230	383	349	273	306	51	281	145	204	265	89	68	385	120	391	83	273	177	329	361	235	236	320	253	471	51
15	236	360	417	358	298	358	170	340	85	264	68	162	323	32	136	307	83	378	62	358	353	200	345	138	69	247	236	417	32
16	234	171	417	170	273	341	247	366	374	298	60	281	105	48	392	147	215	379	60	240	266	362	62	171	174	3	225	417	3
17	232	283	298	426	324	153	128	17	349	315	213	323	96	23	442	359	133	318	55	166	45	364	366	289	77	320	235	442	17
18	234	214	234	315	341	375	400	9	366	25	9	170	87	26	348	301	364	336	246	360	94	350	249	201	185	295	236	400	9
19	218	326	218	333	170	341	383	366	213	128	128	238	177	25	178	130	236	303	301	316	51	277	36	202	159	294	221	383	25
20	222	86	366	281	85	213	366	357	391	323	43	68	326	97	128	164	195	335	347	339	118	102	59	389	141	340	226	391	43
21	244	171	460	128	170	239	341	340	374	298	51	323	315	121	426	52	156	62	261	182	106	353	339	274	321	336	248	460	51
22	214	103	409	290	213	136	290	332	196	238	60	128	316	140	298	128	68	55	112	331	60	352	341	203	336	326	218	409	55
23	196	446	281	298	204	128	341	306	332	162	306	94	295	59	142	88	126	86	91	220	47	106	350	172	30	260	199	446	30
24	206	471	85	85	290	111	383	247	357	221	213	128	33	34	331	81	319	358	85	158	275	146	335	151	38	186	205	471	33
25	212	283	195	129	213	341	341	128	332	272	51	298	318	47	194	231	331	59	238	165	185	335	315	61	37	157	210	341	37
26	205	189	391	256	102	256	366	281	179	145	374	102	317	65	82	311	51	354	45	242	137	346	186	102	43	56	199	391	43
27	158	334	196	383	145	128	26	60	264	298	221	68	315	78	70	80	129	205	159	48	32	177	96	214	56	60	154	383	26
28	191	26	426	256	383	77	256	340	247	170	281	258	319	29	43	59	163	353	267	128	226	52	51	138	33	275	194	426	26
29	269	394	469	392	426	68	341	349	272	298	170	272	267	59	350	55	196	230	337	337	306	333	339	80	108	256	268	469	55
30	253	394	469	375	324	298	136	306	340	213	340	255	40	131	334	61	162	367	322	322	80	335	326	74	64	113	247	469	40
TOTAL	7514	9889	10091	7781	7625	8094	7831	8440	9259	8304	6878	6325	7163	1929	8058	6514	7181	9125	7283	8683	6222	8492	7829	6602	4698	7949	7526	13432	1271

Table 23. Daily total solar radiation (Cal/cm²/day), 1962-87, Stoneville, December.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	239	266	417	341	290	256	85	306	162	255	298	299	41	320	328	220	266	349	245	322	197	61	273	95	53	285	241	417	41
2	244	257	239	213	170	85	298	306	255	68	306	304	301	310	328	316	297	348	156	313	168	252	318	177	69	304	246	348	68
3	216	429	136	85	128	290	341	323	255	68	196	81	302	310	332	162	100	329	328	326	50	88	76	363	82	284	218	429	50
4	240	437	34	324	170	315	298	340	349	77	51	293	285	264	319	187	64	320	307	408	61	103	293	158	301	308	243	437	34
5	235	386	230	324	290	213	332	128	170	26	102	206	283	238	317	308	344	316	264	333	203	252	59	69	253	273	237	386	26
6	201	137	307	392	119	153	213	9	340	17	323	299	55	94	36	339	251	280	147	167	281	227	49	316	266	150	199	392	9
7	216	189	264	392	213	119	341	77	340	68	230	283	53	60	64	233	117	331	90	193	307	274	318	318	305	118	212	392	53
8	224	394	426	392	153	128	341	213	315	119	26	228	92	51	324	107	36	326	125	326	294	311	330	251	75	84	219	426	26
9	212	343	256	256	85	52	298	213	162	68	43	223	297	196	321	317	245	322	64	320	53	287	296	271	84	278	215	343	43
10	210	86	60	222	170	119	281	272	272	349	43	292	232	289	178	330	333	326	104	316	46	190	195	288	36	283	212	349	36
11	170	43	77	111	111	119	290	340	187	281	85	230	157	213	52	271	331	290	316	54	34	56	292	185	62	228	172	340	34
12	179	77	281	290	9	179	85	298	196	102	152	176	189	280	42	182	332	43	315	112	267	144	298	54	187	290	183	332	9
13	196	60	307	290	94	273	341	289	315	136	170	286	130	232	263	36	307	67	290	79	309	61	95	47	229	26	190	341	26
14	204	411	426	26	341	34	375	332	340	111	60	262	246	247	102	78	278	318	279	73	73	61	164	71	195	114	201	426	26
15	208	343	392	17	256	43	341	349	85	238	162	110	286	85	275	158	111	252	163	300	120	288	213	319	67	298	211	392	17
16	218	334	324	51	230	170	298	289	85	85	357	71	274	136	323	227	88	297	191	295	238	304	226	321	53	303	221	357	51
17	225	300	85	247	136	26	162	264	289	162	356	279	266	68	278	195	334	339	303	355	291	56	167	309	225	297	228	366	26
18	238	334	383	51	281	153	170	204	238	315	68	287	230	298	259	293	72	347	297	328	161	308	123	282	238	110	233	383	51
19	220	300	256	298	256	256	290	306	179	119	51	39	276	238	110	247	213	319	56	321	304	235	201	121	220	65	214	321	39
20	182	51	341	298	307	119	273	145	9	238	34	114	239	264	262	240	168	96	79	159	291	48	102	306	182	141	181	341	9
21	186	257	111	315	153	119	43	51	119	315	54	210	279	272	306	213	328	176	308	41	271	70	107	154	186	102	183	328	41
22	199	34	315	256	119	366	119	199	60	323	158	277	281	221	176	318	325	56	91	165	193	35	327	161	199	257	202	366	34
23	199	399	281	170	43	324	315	199	162	315	155	144	71	221	321	118	256	60	98	104	153	156	333	288	199	172	198	399	43
24	181	317	239	43	341	298	281	181	315	153	312	14	91	34	296	80	140	107	85	58	202	104	159	308	181	65	176	341	14
25	244	266	290	392	273	298	315	244	315	255	283	186	26	12	50	305	334	324	291	313	92	265	265	224	244	83	238	392	12
26	210	206	119	332	85	341	153	210	323	77	378	193	14	85	329	336	171	316	146	184	39	277	188	323	210	35	203	378	14
27	208	429	85	298	119	153	68	208	298	102	250	293	17	170	253	331	284	242	236	301	100	141	107	309	208	17	201	429	17
28	214	326	315	247	213	213	298	77	213	85	114	280	60	280	326	237	304	169	306	258	204	46	235	120	214	289	217	326	46
29	177	360	170	281	366	196	290	9	204	77	45	149	21	68	322	50	57	56	274	294	249	69	157	311	177	173	177	366	9
30	166	351	213	153	119	136	119	42	68	170	374	120	51	34	70	82	43	133	295	191	218	324	205	315	166	135	167	374	34
31	160	163	298	153	119	43	213	17	153	119	160	34	136	238	324	64	59	71	304	77	229	320	104	274	160	33	155	324	17
TOTAL	6421	8285	7677	7260	5759	5605	7667	6440	6773	4893	5416	6261	5281	5834	7286	6580	6583	7255	6552	6966	5698	5413	6186	7128	5326	5650	6393	11541	955

Table 24. Daylength (hours), North Mississippi (Water Valley).

latitude 34.2

Month

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	9.8	10.3	11.2	12.4	13.4	14.1	14.2	13.7	12.7	11.6	10.6	9.9
2	9.8	10.4	11.3	12.4	13.4	14.1	14.2	13.7	12.7	11.6	10.5	9.8
3	9.8	10.4	11.3	12.4	13.4	14.2	14.2	13.6	12.6	11.5	10.5	9.8
4	9.8	10.4	11.3	12.5	13.5	14.2	14.2	13.6	12.6	11.5	10.5	9.8
5	9.8	10.5	11.4	12.5	13.5	14.2	14.2	13.6	12.6	11.5	10.4	9.8
6	9.8	10.5	11.4	12.5	13.5	14.2	14.2	13.6	12.5	11.4	10.4	9.8
7	9.8	10.5	11.5	12.6	13.6	14.2	14.2	13.5	12.5	11.4	10.4	9.8
8	9.8	10.6	11.5	12.6	13.6	14.2	14.2	13.5	12.5	11.4	10.4	9.8
9	9.9	10.6	11.5	12.7	13.6	14.2	14.2	13.5	12.4	11.3	10.3	9.8
10	9.9	10.6	11.6	12.7	13.7	14.2	14.2	13.4	12.4	11.3	10.3	9.8
11	9.9	10.6	11.6	12.7	13.7	14.2	14.1	13.4	12.3	11.3	10.3	9.8
12	9.9	10.7	11.6	12.8	13.7	14.3	14.1	13.4	12.3	11.2	10.3	9.7
13	9.9	10.7	11.7	12.8	13.7	14.3	14.1	13.3	12.3	11.2	10.2	9.7
14	9.9	10.7	11.7	12.8	13.8	14.3	14.1	13.3	12.2	11.2	10.2	9.7
15	10.0	10.8	11.7	12.9	13.8	14.3	14.1	13.3	12.2	11.1	10.2	9.7
16	10.0	10.8	11.8	12.9	13.8	14.3	14.1	13.2	12.2	11.1	10.2	9.7
17	10.0	10.8	11.8	12.9	13.8	14.3	14.0	13.2	12.1	11.1	10.1	9.7
18	10.0	10.9	11.9	13.0	13.9	14.3	14.0	13.2	12.1	11.0	10.1	9.7
19	10.0	10.9	11.9	13.0	13.9	14.3	14.0	13.2	12.1	11.0	10.1	9.7
20	10.1	10.9	11.9	13.0	13.9	14.3	14.0	13.1	12.0	10.9	10.1	9.7
21	10.1	11.0	12.0	13.1	13.9	14.3	14.0	13.1	12.0	10.9	10.0	9.7
22	10.1	11.0	12.0	13.1	13.9	14.3	13.9	13.1	11.9	10.9	10.0	9.7
23	10.1	11.0	12.0	13.1	14.0	14.3	13.9	13.0	11.9	10.8	10.0	9.7
24	10.1	11.1	12.1	13.2	14.0	14.3	13.9	13.0	11.9	10.8	10.0	9.7
25	10.2	11.1	12.1	13.2	14.0	14.3	13.9	12.9	11.8	10.8	10.0	9.7
26	10.2	11.1	12.1	13.2	14.0	14.3	13.8	12.9	11.8	10.8	9.9	9.7
27	10.2	11.2	12.2	13.3	14.0	14.3	13.8	12.9	11.8	10.7	9.9	9.7
28	10.2	11.2	12.2	13.3	14.1	14.3	13.8	12.8	11.7	10.7	9.9	9.7
29	10.3		12.3	13.3	14.1	14.3	13.8	12.8	11.7	10.7	9.9	9.7
30	10.3		12.3	13.4	14.1	14.3	13.7	12.8	11.7	10.6	9.9	9.7
31	10.3		12.3		14.1		13.7	12.7		10.6		9.8

Table 25. Daylength (hours), Central Mississippi (Canton).

latitude 32.6

Month

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	9.9	10.4	11.3	12.3	13.3	14.0	14.1	13.6	12.7	11.6	10.7	10.0
2	9.9	10.5	11.3	12.4	13.3	14.0	14.1	13.6	12.6	11.6	10.6	10.0
3	9.9	10.5	11.4	12.4	13.4	14.0	14.1	13.5	12.6	11.6	10.6	10.0
4	9.9	10.5	11.4	12.4	13.4	14.0	14.1	13.5	12.6	11.5	10.6	10.0
5	9.9	10.6	11.4	12.5	13.4	14.1	14.1	13.5	12.5	11.5	10.5	9.9
6	9.9	10.6	11.5	12.5	13.4	14.1	14.1	13.5	12.5	11.5	10.5	9.9
7	10.0	10.6	11.5	12.5	13.5	14.1	14.1	13.4	12.5	11.4	10.5	9.9
8	10.0	10.6	11.5	12.6	13.5	14.1	14.0	13.4	12.4	11.4	10.5	9.9
9	10.0	10.7	11.6	12.6	13.5	14.1	14.0	13.4	12.4	11.4	10.4	9.9
10	10.0	10.7	11.6	12.6	13.6	14.1	14.0	13.3	12.4	11.3	10.4	9.9
11	10.0	10.7	11.6	12.7	13.6	14.1	14.0	13.3	12.3	11.3	10.4	9.9
12	10.0	10.8	11.7	12.7	13.6	14.1	14.0	13.3	12.3	11.3	10.4	9.9
13	10.0	10.8	11.7	12.7	13.6	14.1	14.0	13.3	12.3	11.2	10.3	9.9
14	10.1	10.8	11.7	12.8	13.7	14.1	14.0	13.2	12.2	11.2	10.3	9.9
15	10.1	10.8	11.8	12.8	13.7	14.1	13.9	13.2	12.2	11.2	10.3	9.9
16	10.1	10.9	11.8	12.8	13.7	14.1	13.9	13.2	12.2	11.1	10.3	9.9
17	10.1	10.9	11.8	12.9	13.7	14.1	13.9	13.1	12.1	11.1	10.2	9.9
18	10.1	10.9	11.9	12.9	13.7	14.1	13.9	13.1	12.1	11.1	10.2	9.9
19	10.2	11.0	11.9	12.9	13.8	14.1	13.9	13.1	12.1	11.0	10.2	9.9
20	10.2	11.0	11.9	13.0	13.8	14.1	13.9	13.1	12.0	11.0	10.2	9.9
21	10.2	11.0	12.0	13.0	13.8	14.1	13.8	13.0	12.0	11.0	10.2	9.9
22	10.2	11.1	12.0	13.0	13.8	14.1	13.8	13.0	11.9	10.9	10.1	9.9
23	10.2	11.1	12.0	13.1	13.8	14.1	13.8	13.0	11.9	10.9	10.1	9.9
24	10.3	11.1	12.1	13.1	13.9	14.1	13.8	12.9	11.9	10.9	10.1	9.9
25	10.3	11.2	12.1	13.1	13.9	14.1	13.8	12.9	11.8	10.9	10.1	9.9
26	10.3	11.2	12.1	13.2	13.9	14.1	13.7	12.9	11.8	10.8	10.1	9.9
27	10.3	11.2	12.2	13.2	13.9	14.1	13.7	12.8	11.8	10.8	10.1	9.9
28	10.3	11.3	12.2	13.2	13.9	14.1	13.7	12.8	11.7	10.8	10.0	9.9
29	10.4		12.2	13.2	14.0	14.1	13.7	12.8	11.7	10.7	10.0	9.9
30	10.4		12.3	13.3	14.0	14.1	13.6	12.7	11.7	10.7	10.0	9.9
31	10.4		12.3		14.0		13.6	12.7		10.7		9.9

Table 26. Daylength (hours), South Mississippi (Hattiesburg).

latitude 31.3

Month

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	10.0	10.5	11.3	12.3	13.2	13.9	14.0	13.5	12.6	11.7	10.7	10.1
2	10.0	10.5	11.4	12.4	13.3	13.9	14.0	13.5	12.6	11.6	10.7	10.1
3	10.0	10.6	11.4	12.4	13.3	13.9	14.0	13.5	12.6	11.6	10.7	10.1
4	10.0	10.6	11.4	12.4	13.3	13.9	14.0	13.4	12.5	11.6	10.6	10.1
5	10.0	10.6	11.4	12.5	13.3	13.9	14.0	13.4	12.5	11.5	10.6	10.0
6	10.1	10.7	11.5	12.5	13.4	14.0	14.0	13.4	12.5	11.5	10.6	10.0
7	10.1	10.7	11.5	12.5	13.4	14.0	14.0	13.4	12.4	11.5	10.6	10.0
8	10.1	10.7	11.5	12.6	13.4	14.0	13.9	13.3	12.4	11.4	10.5	10.0
9	10.1	10.7	11.6	12.6	13.5	14.0	13.9	13.3	12.4	11.4	10.5	10.0
10	10.1	10.8	11.6	12.6	13.5	14.0	13.9	13.3	12.3	11.4	10.5	10.0
11	10.1	10.8	11.6	12.6	13.5	14.0	13.9	13.3	12.3	11.3	10.5	10.0
12	10.1	10.8	11.7	12.7	13.5	14.0	13.9	13.2	12.3	11.3	10.4	10.0
13	10.1	10.8	11.7	12.7	13.5	14.0	13.9	13.2	12.2	11.3	10.4	10.0
14	10.2	10.9	11.7	12.7	13.6	14.0	13.9	13.2	12.2	11.2	10.4	10.0
15	10.2	10.9	11.8	12.8	13.6	14.0	13.8	13.1	12.2	11.2	10.4	10.0
16	10.2	10.9	11.8	12.8	13.6	14.0	13.8	13.1	12.1	11.2	10.4	10.0
17	10.2	11.0	11.8	12.8	13.6	14.0	13.8	13.1	12.1	11.2	10.3	10.0
18	10.2	11.0	11.9	12.9	13.7	14.0	13.8	13.1	12.1	11.1	10.3	10.0
19	10.2	11.0	11.9	12.9	13.7	14.0	13.8	13.0	12.0	11.1	10.3	10.0
20	10.3	11.0	11.9	12.9	13.7	14.0	13.8	13.0	12.0	11.1	10.3	10.0
21	10.3	11.1	12.0	13.0	13.7	14.0	13.7	13.0	12.0	11.0	10.3	10.0
22	10.3	11.1	12.0	13.0	13.7	14.0	13.7	12.9	12.0	11.0	10.2	10.0
23	10.3	11.1	12.0	13.0	13.8	14.0	13.7	12.9	11.9	11.0	10.2	10.0
24	10.3	11.2	12.1	13.0	13.8	14.0	13.7	12.9	11.9	10.9	10.2	10.0
25	10.4	11.2	12.1	13.1	13.8	14.0	13.7	12.8	11.9	10.9	10.2	10.0
26	10.4	11.2	12.1	13.1	13.8	14.0	13.6	12.8	11.8	10.9	10.2	10.0
27	10.4	11.3	12.2	13.1	13.8	14.0	13.6	12.8	11.8	10.9	10.2	10.0
28	10.4	11.3	12.2	13.2	13.8	14.0	13.6	12.8	11.8	10.8	10.1	10.0
29	10.5		12.2	13.2	13.9	14.0	13.6	12.7	11.7	10.8	10.1	10.0
30	10.5		12.3	13.2	13.9	14.0	13.6	12.7	11.7	10.8	10.1	10.0
31	10.5		12.3		13.9		13.5	12.7		10.7		10.0

Table 27. Daily evaporation (inches), 1962-1987, Stoneville, January.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.02	0.06	0.05	0.05	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.00	0.02	0.00	0.02	0.05	0.05	0.02	0.00	0.02	0.00	0.00	0.03	0.02	0.00
2	0.01	0.07	0.06	0.12	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.01	0.00	0.02	0.01	0.04	0.00	0.00	0.06	0.00	0.00	0.02	0.12	0.00
3	0.01	0.05	0.06	0.14	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.01	0.00	0.00	0.01	0.05	0.03	0.00	0.00	0.00	0.00	0.02	0.14	0.00
4	0.02	0.07	0.12	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.02	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.17	0.04	0.03	0.17	0.00
5	0.01	0.06	0.08	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.01	0.00	0.02	0.01	0.09	0.00	0.00	0.00	0.00	0.04	0.02	0.09	0.00
6	0.01	0.01	0.06	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.05	0.01	0.09	0.00	0.00	0.00	0.00	0.07	0.02	0.09	0.00
7	0.02	0.01	0.01	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.05	0.02	0.00	0.09	0.02	0.14	0.07	0.01	0.00	0.00	0.05	0.03	0.14	0.00
8	0.01	0.05	0.03	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.05	0.01	0.00	0.00	0.01	0.00	0.04	0.06	0.00	0.00	0.07	0.02	0.10	0.00
9	0.01	0.06	0.02	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.06	0.02	0.02	0.00
10	0.02	0.08	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.00	0.02	0.00	0.07	0.02	0.00	0.01	0.13	0.00	0.00	0.03	0.03	0.13	0.00
11	0.01	0.07	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.04	0.01	0.00	0.07	0.00	0.06	0.00	0.00	0.02	0.07	0.00
12	0.01	0.03	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.00	0.01	0.00	0.16	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.16	0.00
13	0.01	0.03	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.00
14	0.01	0.03	0.04	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.00	0.01	0.00	0.00	0.01	0.00	0.07	0.00	0.00	0.00	0.05	0.02	0.07	0.00
15	0.02	0.03	0.04	0.10	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.13	0.00	0.02	0.00	0.06	0.02	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.13	0.00
16	0.01	0.03	0.04	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.09	0.00
17	0.01	0.02	0.05	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.00	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.07	0.05	0.03	0.02	0.09	0.00
18	0.02	0.02	0.05	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.09	0.00	0.02	0.03	0.04	0.02	0.00	0.00	0.00	0.03	0.05	0.10	0.03	0.10	0.00
19	0.02	0.01	0.04	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.11	0.00	0.02	0.00	0.10	0.02	0.00	0.00	0.00	0.06	0.05	0.00	0.03	0.11	0.00
20	0.02	0.02	0.15	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.00	0.02	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.09	0.00	0.03	0.15	0.00
21	0.02	0.03	0.12	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.09	0.00	0.02	0.00	0.05	0.01	0.01	0.00	0.00	0.00	0.11	0.00	0.03	0.12	0.00
22	0.03	0.03	0.20	0.10	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.11	0.00	0.03	0.00	0.04	0.02	0.05	0.00	0.00	0.00	0.15	0.00	0.04	0.20	0.00
23	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.13	0.00	0.02	0.00	0.05	0.01	0.12	0.00	0.00	0.00	0.06	0.00	0.03	0.12	0.00
24	0.02	0.00	0.11	0.08	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.02	0.00	0.05	0.07	0.00	0.00	0.01	0.00	0.06	0.00	0.02	0.11	0.00
25	0.02	0.00	0.07	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.15	0.00	0.02	0.00	0.06	0.11	0.00	0.00	0.01	0.00	0.06	0.06	0.03	0.15	0.00
26	0.03	0.00	0.07	0.21	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.03	0.00	0.07	0.10	0.00	0.07	0.03	0.00	0.08	0.00	0.04	0.21	0.00
27	0.02	0.00	0.15	0.15	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.09	0.00	0.02	0.00	0.03	0.02	0.00	0.03	0.03	0.00	0.09	0.00	0.03	0.15	0.00
28	0.03	0.00	0.07	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.03	0.00	0.03	0.11	0.00	0.03	0.03	0.00	0.09	0.03	0.04	0.15	0.00
29	0.03	0.00	0.09	0.15	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.11	0.00	0.03	0.00	0.00	0.09	0.12	0.03	0.00	0.00	0.10	0.10	0.04	0.16	0.00
30	0.02	0.00	0.09	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.09	0.00	0.02	0.00	0.00	0.12	0.03	0.05	0.12	0.00	0.00	0.13	0.04	0.13	0.00
31	0.02	0.02	0.08	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.00	0.02	0.00	0.00	0.05	0.16	0.03	0.12	0.03	0.00	0.18	0.04	0.18	0.00
TOTAL	0.54	0.92	2.12	2.55	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	1.95	0.12	0.54	0.03	1.17	1.32	1.02	0.58	0.81	0.39	1.21	1.05	0.35	3.92	0.00

Table 28. Daily evaporation (inches), 1962-1987, Stoneville, February.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.03	0.06	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.14	0.00	0.03	0.00	0.00	0.02	0.00	0.25	0.09	0.00	0.10	0.14	0.05	0.25	0.00
2	0.02	0.03	0.14	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.12	0.00	0.02	0.00	0.00	0.02	0.00	0.06	0.12	0.00	0.03	0.21	0.04	0.21	0.00
3	0.02	0.07	0.11	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.10	0.00	0.02	0.02	0.00	0.02	0.03	0.06	0.07	0.00	0.11	0.05	0.04	0.11	0.00
4	0.03	0.07	0.15	0.06	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.10	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.11	0.00	0.19	0.11	0.05	0.19	0.00
5	0.02	0.06	0.08	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.14	0.14	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.11	0.00	0.00	0.08	0.04	0.14	0.00
6	0.02	0.13	0.02	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.02	0.07	0.00	0.02	0.00	0.00	0.00	0.00	0.12	0.06	0.03	0.13	0.00
7	0.03	0.18	0.06	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.12	0.00	0.00	0.03	0.02	0.00	0.03	0.00	0.11	0.00	0.00	0.14	0.00	0.04	0.18	0.00
8	0.03	0.06	0.08	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.15	0.19	0.00	0.03	0.00	0.00	0.03	0.00	0.06	0.00	0.00	0.10	0.09	0.04	0.19	0.00
9	0.04	0.07	0.09	0.17	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.11	0.14	0.00	0.04	0.00	0.08	0.10	0.02	0.04	0.12	0.00	0.15	0.00	0.06	0.17	0.00
10	0.04	0.07	0.18	0.18	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.10	0.11	0.12	0.04	0.00	0.00	0.14	0.00	0.12	0.02	0.00	0.03	0.00	0.06	0.18	0.00
11	0.02	0.10	0.11	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.12	0.08	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.07	0.00	0.00	0.00	0.03	0.12	0.00
12	0.04	0.10	0.11	0.25	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.08	0.04	0.04	0.05	0.00	0.04	0.00	0.04	0.23	0.00	0.00	0.07	0.06	0.25	0.00
13	0.03	0.10	0.11	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.10	0.11	0.03	0.03	0.00	0.03	0.04	0.06	0.02	0.00	0.00	0.12	0.05	0.12	0.00
14	0.03	0.10	0.07	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.08	0.10	0.00	0.03	0.12	0.00	0.03	0.00	0.08	0.07	0.10	0.00	0.16	0.05	0.16	0.00
15	0.04	0.10	0.08	0.08	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.13	0.00	0.04	0.17	0.03	0.04	0.00	0.09	0.14	0.12	0.00	0.14	0.06	0.17	0.00
16	0.04	0.10	0.13	0.08	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.11	0.00	0.04	0.00	0.06	0.04	0.00	0.11	0.18	0.11	0.00	0.00	0.05	0.18	0.00
17	0.05	0.11	0.11	0.02	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.09	0.20	0.11	0.05	0.00	0.00	0.05	0.10	0.09	0.15	0.11	0.05	0.04	0.07	0.20	0.00
18	0.05	0.11	0.12	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.12	0.18	0.14	0.05	0.00	0.00	0.03	0.08	0.12	0.11	0.11	0.15	0.02	0.07	0.18	0.00
19	0.04	0.07	0.04	0.11	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.16	0.00	0.04	0.00	0.00	0.05	0.04	0.07	0.14	0.11	0.11	0.03	0.06	0.16	0.00
20	0.05	0.02	0.07	0.18	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.11	0.22	0.00	0.05	0.01	0.04	0.13	0.07	0.13	0.09	0.02	0.11	0.06	0.07	0.22	0.00
21	0.08	0.15	0.08	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.20	0.22	0.08	0.06	0.17	0.16	0.13	0.17	0.06	0.11	0.20	0.00	0.11	0.22	0.00
22	0.06	0.08	0.08	0.13	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.14	0.24	0.06	0.03	0.14	0.08	0.17	0.09	0.11	0.13	0.06	0.02	0.09	0.24	0.02
23	0.06	0.08	0.08	0.13	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.15	0.13	0.06	0.06	0.15	0.19	0.14	0.04	0.10	0.12	0.05	0.03	0.08	0.19	0.03
24	0.09	0.08	0.09	0.14	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.14	0.21	0.15	0.09	0.15	0.13	0.19	0.22	0.08	0.20	0.23	0.14	0.07	0.12	0.23	0.07
25	0.08	0.14	0.15	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.10	0.09	0.26	0.08	0.00	0.19	0.14	0.17	0.08	0.15	0.10	0.21	0.08	0.11	0.26	0.00
26	0.05	0.14	0.08	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.13	0.15	0.25	0.05	0.00	0.00	0.17	0.04	0.00	0.15	0.01	0.11	0.05	0.07	0.25	0.00
27	0.05	0.13	0.05	0.09	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.19	0.07	0.05	0.00	0.00	0.15	0.00	0.00	0.20	0.03	0.21	0.03	0.07	0.21	0.00
28	0.07	0.13	0.02	0.19	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.12	0.18	0.11	0.05	0.12	0.16	0.19	0.02	0.04	0.03	0.13	0.18	0.00	0.09	0.19	0.00
TOTAL	1.21	2.64	2.54	2.73	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	2.28	3.71	1.95	1.19	0.91	1.15	2.16	1.27	1.99	2.84	1.54	2.55	1.66	1.76	5.30	0.12

Table 29. Daily evaporation (inches), 1962-1987, Stoneville, March.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.05	0.15	0.13	0.09	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.14	0.12	0.16	0.08	0.10	0.03	0.08	0.06	0.01	0.00	0.06	0.00	0.00	0.06	0.16	0.00
2	0.06	0.07	0.14	0.02	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.13	0.15	0.16	0.06	0.32	0.00	0.04	0.12	0.12	0.16	0.00	0.11	0.08	0.09	0.32	0.00
3	0.05	0.14	0.06	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.18	0.00	0.05	0.15	0.00	0.11	0.17	0.01	0.04	0.09	0.03	0.12	0.07	0.18	0.00
4	0.05	0.23	0.06	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.16	0.16	0.05	0.00	0.00	0.07	0.09	0.13	0.02	0.19	0.17	0.20	0.08	0.23	0.00
5	0.05	0.12	0.07	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.13	0.35	0.08	0.05	0.00	0.04	0.05	0.13	0.00	0.00	0.05	0.18	0.17	0.07	0.35	0.00
6	0.07	0.24	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.05	0.13	0.08	0.16	0.00	0.06	0.13	0.16	0.06	0.14	0.28	0.15	0.10	0.28	0.00
7	0.08	0.24	0.18	0.05	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.17	0.23	0.15	0.06	0.08	0.18	0.06	0.00	0.25	0.07	0.13	0.17	0.16	0.11	0.25	0.00
8	0.08	0.19	0.24	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.17	0.11	0.19	0.04	0.10	0.04	0.11	0.00	0.28	0.16	0.06	0.26	0.09	0.11	0.28	0.00
9	0.08	0.19	0.05	0.17	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.17	0.01	0.12	0.01	0.24	0.13	0.13	0.00	0.11	0.19	0.11	0.27	0.02	0.10	0.27	0.00
10	0.07	0.10	0.15	0.16	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.11	0.06	0.14	0.12	0.00	0.12	0.12	0.10	0.07	0.12	0.13	0.29	0.22	0.11	0.29	0.00
11	0.08	0.24	0.27	0.16	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.11	0.11	0.14	0.00	0.18	0.11	0.18	0.06	0.00	0.20	0.28	0.09	0.12	0.28	0.00
12	0.07	0.11	0.10	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.13	0.20	0.07	0.19	0.24	0.15	0.07	0.07	0.04	0.16	0.22	0.06	0.10	0.24	0.04
13	0.06	0.13	0.17	0.04	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.17	0.19	0.08	0.12	0.03	0.14	0.10	0.09	0.10	0.21	0.05	0.12	0.09	0.21	0.03
14	0.09	0.28	0.20	0.11	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.06	0.04	0.21	0.15	0.21	0.21	0.22	0.12	0.18	0.11	0.16	0.11	0.12	0.13	0.28	0.04
15	0.08	0.17	0.22	0.11	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.06	0.08	0.24	0.18	0.17	0.12	0.22	0.09	0.13	0.08	0.07	0.16	0.25	0.12	0.25	0.06
16	0.07	0.00	0.00	0.13	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.03	0.23	0.12	0.07	0.19	0.10	0.14	0.11	0.21	0.16	0.09	0.13	0.10	0.23	0.00
17	0.08	0.03	0.17	0.23	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.06	0.11	0.06	0.17	0.21	0.07	0.22	0.14	0.04	0.17	0.20	0.08	0.23	0.12	0.23	0.03
18	0.10	0.27	0.18	0.14	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.21	0.20	0.28	0.19	0.08	0.34	0.09	0.08	0.05	0.22	0.17	0.35	0.15	0.35	0.05
19	0.10	0.15	0.22	0.15	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.21	0.13	0.24	0.22	0.15	0.10	0.15	0.15	0.13	0.17	0.09	0.09	0.14	0.24	0.09
20	0.11	0.31	0.17	0.15	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.22	0.23	0.16	0.27	0.18	0.08	0.11	0.21	0.15	0.14	0.25	0.16	0.27	0.16	0.31	0.08
21	0.08	0.27	0.07	0.15	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.21	0.22	0.16	0.11	0.06	0.18	0.19	0.17	0.10	0.11	0.02	0.00	0.16	0.11	0.27	0.00
22	0.09	0.21	0.21	0.16	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.17	0.23	0.10	0.19	0.14	0.12	0.19	0.08	0.08	0.21	0.06	0.00	0.17	0.12	0.23	0.00
23	0.09	0.17	0.07	0.21	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.13	0.20	0.27	0.21	0.18	0.17	0.04	0.17	0.13	0.20	0.04	0.00	0.20	0.13	0.27	0.00
24	0.09	0.24	0.12	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.29	0.18	0.12	0.12	0.22	0.11	0.17	0.14	0.05	0.16	0.04	0.20	0.18	0.12	0.29	0.00
25	0.09	0.23	0.19	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.21	0.03	0.19	0.05	0.17	0.19	0.14	0.13	0.15	0.15	0.20	0.19	0.22	0.13	0.23	0.03
26	0.10	0.10	0.10	0.19	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.23	0.05	0.23	0.06	0.22	0.10	0.14	0.20	0.19	0.16	0.19	0.27	0.20	0.14	0.27	0.05
27	0.11	0.29	0.18	0.04	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.16	0.23	0.36	0.14	0.09	0.03	0.24	0.27	0.08	0.22	0.22	0.18	0.19	0.15	0.36	0.03
28	0.10	0.25	0.18	0.05	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.15	0.21	0.32	0.17	0.25	0.03	0.21	0.17	0.24	0.08	0.08	0.00	0.15	0.14	0.32	0.00
29	0.09	0.27	0.21	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.13	0.10	0.19	0.27	0.07	0.32	0.17	0.10	0.04	0.20	0.20	0.19	0.14	0.32	0.04
30	0.10	0.30	0.16	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.28	0.21	0.18	0.13	0.07	0.21	0.14	0.15	0.17	0.29	0.14	0.14	0.30	0.00
31	0.15	0.30	0.20	0.07	0.15	0.27	0.15	0.09	0.14	0.28	0.15	0.15	0.15	0.12	0.13	0.23	0.41	0.18	0.14	0.23	0.15	0.08	0.20	0.23	0.26	0.00	0.18	0.41	0.00
TOTAL	2.57	5.99	4.54	2.99	2.57	2.69	2.57	2.51	2.56	2.70	2.57	2.57	2.57	4.08	4.44	5.38	4.16	4.67	3.13	4.48	3.95	3.54	3.65	4.21	4.76	4.72	3.63	8.50	0.57

Table 30. Daily evaporation (inches), 1962-1987, Stoneville, April.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.24	0.30	0.21	0.12	0.16	0.22	0.16	0.25	0.16	0.12	0.21	0.23	0.21	0.13	0.21	0.03	0.39	0.00	0.12	0.22	0.18	0.14	0.09	0.17	0.27	0.00	0.17	0.39	0.00
2	0.18	0.30	0.23	0.15	0.27	0.20	0.16	0.13	0.11	0.19	0.21	0.20	0.23	0.24	0.20	0.11	0.30	0.15	0.09	0.23	0.00	0.19	0.13	0.17	0.23	0.24	0.19	0.30	0.00
3	0.16	0.27	0.24	0.17	0.16	0.15	0.20	0.22	0.10	0.20	0.22	0.19	0.36	0.15	0.21	0.10	0.31	0.04	0.14	0.28	0.21	0.04	0.25	0.23	0.28	0.09	0.19	0.36	0.04
4	0.08	0.27	0.23	0.03	0.20	0.20	0.17	0.25	0.20	0.25	0.37	0.13	0.18	0.21	0.22	0.18	0.11	0.15	0.12	0.24	0.22	0.15	0.26	0.30	0.25	0.00	0.19	0.37	0.00
5	0.02	0.31	0.10	0.07	0.27	0.32	0.19	0.17	0.17	0.21	0.11	0.18	0.22	0.20	0.28	0.20	0.39	0.16	0.24	0.10	0.20	0.13	0.15	0.38	0.25	0.00	0.19	0.39	0.00
6	0.06	0.05	0.20	0.21	0.28	0.28	0.15	0.06	0.26	0.11	0.15	0.17	0.18	0.22	0.13	0.24	0.32	0.23	0.20	0.23	0.24	0.01	0.19	0.17	0.20	0.17	0.18	0.32	0.01
7	0.08	0.02	0.00	0.20	0.31	0.28	0.13	0.17	0.24	0.20	0.11	0.10	0.23	0.09	0.23	0.28	0.28	0.23	0.23	0.17	0.17	0.05	0.20	0.13	0.21	0.15	0.17	0.31	0.00
8	0.17	0.17	0.21	0.00	0.15	0.22	0.11	0.20	0.21	0.26	0.25	0.24	0.24	0.01	0.27	0.25	0.24	0.14	0.19	0.20	0.13	0.01	0.33	0.28	0.32	0.18	0.19	0.33	0.00
9	0.20	0.24	0.31	0.18	0.36	0.30	0.23	0.15	0.18	0.20	0.18	0.21	0.23	0.15	0.35	0.25	0.23	0.19	0.34	0.12	0.08	0.00	0.08	0.24	0.12	0.22	0.21	0.36	0.00
10	0.18	0.19	0.21	0.24	0.27	0.18	0.03	0.25	0.20	0.23	0.23	0.19	0.28	0.20	0.37	0.30	0.22	0.10	0.27	0.14	0.13	0.15	0.09	0.24	0.24	0.27	0.21	0.37	0.03
11	0.12	0.26	0.17	0.19	0.07	0.05	0.20	0.27	0.08	0.23	0.21	0.19	0.30	0.21	0.11	0.31	0.11	0.00	0.29	0.30	0.08	0.17	0.06	0.29	0.21	0.35	0.19	0.35	0.00
12	0.27	0.25	0.21	0.33	0.23	0.21	0.19	0.10	0.18	0.33	0.23	0.24	0.04	0.24	0.26	0.26	0.07	0.04	0.34	0.25	0.24	0.23	0.20	0.00	0.17	0.27	0.21	0.34	0.00
13	0.21	0.27	0.37	0.27	0.26	0.29	0.24	0.16	0.37	0.37	0.32	0.16	0.16	0.05	0.15	0.26	0.26	0.22	0.16	0.20	0.35	0.27	0.19	0.18	0.10	0.19	0.23	0.37	0.05
14	0.26	0.25	0.00	0.23	0.19	0.12	0.04	0.11	0.25	0.24	0.35	0.23	0.21	0.05	0.05	0.30	0.20	0.22	0.00	0.29	0.03	0.22	0.23	0.19	0.21	0.00	0.17	0.35	0.00
15	0.29	0.22	0.06	0.17	0.06	0.18	0.30	0.18	0.31	0.22	0.35	0.16	0.18	0.14	0.24	0.25	0.22	0.22	0.08	0.33	0.15	0.18	0.29	0.12	0.13	0.22	0.20	0.35	0.06
16	0.18	0.23	0.23	0.26	0.23	0.20	0.18	0.20	0.05	0.24	0.36	0.05	0.25	0.27	0.38	0.31	0.25	0.24	0.19	0.33	0.11	0.18	0.14	0.20	0.33	0.12	0.22	0.38	0.05
17	0.03	0.30	0.28	0.20	0.27	0.29	0.27	0.10	0.10	0.18	0.33	0.06	0.20	0.19	0.32	0.36	0.17	0.24	0.21	0.25	0.25	0.19	0.13	0.24	0.21	0.18	0.21	0.36	0.03
18	0.18	0.30	0.31	0.27	0.15	0.11	0.02	0.13	0.23	0.16	0.25	0.15	0.22	0.28	0.31	0.07	0.42	0.20	0.11	0.22	0.20	0.24	0.22	0.25	0.15	0.22	0.21	0.42	0.02
19	0.27	0.27	0.23	0.26	0.18	0.18	0.18	0.12	0.41	0.28	0.30	0.19	0.24	0.18	0.19	0.17	0.25	0.22	0.19	0.20	0.00	0.10	0.33	0.30	0.30	0.25	0.22	0.41	0.00
20	0.26	0.19	0.17	0.13	0.30	0.18	0.23	0.07	0.33	0.19	0.29	0.27	0.30	0.23	0.30	0.11	0.21	0.08	0.22	0.35	0.00	0.05	0.00	0.34	0.29	0.24	0.21	0.35	0.00
21	0.31	0.22	0.26	0.20	0.01	0.14	0.24	0.20	0.22	0.22	0.20	0.24	0.18	0.25	0.08	0.03	0.28	0.05	0.22	0.26	0.11	0.19	0.23	0.34	0.09	0.27	0.19	0.34	0.01
22	0.25	0.17	0.28	0.25	0.07	0.21	0.07	0.28	0.24	0.16	0.10	0.20	0.13	0.23	0.17	0.08	0.42	0.07	0.27	0.22	0.16	0.20	0.29	0.23	0.23	0.32	0.20	0.42	0.07
23	0.22	0.35	0.25	0.21	0.07	0.16	0.03	0.33	0.34	0.33	0.25	0.04	0.29	0.12	0.25	0.11	0.14	0.00	0.23	0.20	0.19	0.06	0.29	0.33	0.21	0.19	0.20	0.35	0.00
24	0.15	0.24	0.01	0.26	0.07	0.22	0.23	0.22	0.23	0.21	0.27	0.07	0.26	0.31	0.35	0.29	0.13	0.17	0.31	0.05	0.22	0.08	0.21	0.21	0.25	0.34	0.21	0.35	0.01
25	0.22	0.16	0.25	0.28	0.04	0.02	0.28	0.24	0.07	0.25	0.35	0.10	0.20	0.21	0.16	0.23	0.25	0.16	0.25	0.17	0.16	0.18	0.33	0.23	0.29	0.29	0.21	0.35	0.02
26	0.23	0.02	0.10	0.16	0.10	0.30	0.26	0.32	0.08	0.25	0.31	0.13	0.21	0.23	0.28	0.25	0.26	0.11	0.12	0.24	0.18	0.22	0.41	0.26	0.32	0.32	0.22	0.41	0.02
27	0.16	0.18	0.00	0.11	0.25	0.17	0.23	0.19	0.14	0.23	0.20	0.28	0.28	0.24	0.22	0.28	0.25	0.27	0.09	0.28	0.19	0.26	0.13	0.17	0.32	0.26	0.21	0.32	0.00
28	0.17	0.02	0.00	0.17	0.24	0.19	0.32	0.30	0.18	0.33	0.18	0.24	0.33	0.09	0.29	0.35	0.27	0.26	0.11	0.39	0.21	0.20	0.12	0.13	0.31	0.38	0.22	0.39	0.00
29	0.24	0.00	0.32	0.17	0.11	0.24	0.36	0.26	0.22	0.11	0.18	0.26	0.29	0.21	0.35	0.32	0.19	0.10	0.25	0.32	0.22	0.17	0.04	0.14	0.26	0.38	0.22	0.38	0.00
30	0.30	0.24	0.30	0.19	0.18	0.23	0.26	0.25	0.32	0.07	0.22	0.23	0.25	0.17	0.03	0.32	0.29	0.24	0.24	0.26	0.18	0.21	0.22	0.22	0.37	0.41	0.24	0.41	0.03
TOTAL	5.69	6.26	5.74	5.68	5.51	6.04	5.66	5.88	6.18	6.57	7.29	5.33	6.88	5.50	6.96	6.60	7.43	4.50	5.82	7.04	4.79	4.47	5.83	6.68	7.12	6.52	6.08	10.90	0.45

Table 31. Daily evaporation (inches), 1962-1987, Stoneville, May.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.14	0.30	0.27	0.26	0.15	0.22	0.28	0.20	0.07	0.21	0.25	0.20	0.07	0.20	0.03	0.15	0.22	0.25	0.14	0.23	0.16	0.11	0.26	0.28	0.33	0.34	0.20	0.34	0.03
2	0.23	0.24	0.19	0.29	0.13	0.40	0.23	0.28	0.27	0.33	0.11	0.24	0.20	0.16	0.13	0.12	0.31	0.07	0.09	0.15	0.09	0.21	0.09	0.18	0.14	0.43	0.20	0.43	0.07
3	0.22	0.25	0.00	0.26	0.22	0.28	0.27	0.26	0.23	0.19	0.04	0.24	0.20	0.04	0.31	0.18	0.01	0.37	0.11	0.30	0.17	0.30	0.03	0.09	0.35	0.12	0.19	0.37	0.00
4	0.24	0.13	0.19	0.27	0.28	0.12	0.24	0.20	0.24	0.25	0.26	0.26	0.17	0.22	0.30	0.26	0.06	0.11	0.23	0.34	0.22	0.24	0.19	0.30	0.39	0.13	0.22	0.39	0.06
5	0.27	0.22	0.27	0.27	0.27	0.09	0.28	0.28	0.29	0.10	0.25	0.26	0.19	0.22	0.28	0.33	0.19	0.04	0.21	0.24	0.31	0.18	0.17	0.27	0.38	0.22	0.23	0.38	0.04
6	0.25	0.32	0.25	0.31	0.22	0.21	0.33	0.16	0.30	0.19	0.25	0.13	0.28	0.19	0.32	0.31	0.19	0.17	0.25	0.18	0.31	0.26	0.21	0.31	0.38	0.18	0.25	0.38	0.13
7	0.30	0.20	0.43	0.25	0.26	0.18	0.25	0.06	0.28	0.22	0.28	0.10	0.29	0.29	0.18	0.32	0.24	0.22	0.33	0.25	0.25	0.41	0.31	0.13	0.23	0.14	0.25	0.43	0.06
8	0.30	0.40	0.15	0.32	0.23	0.31	0.24	0.13	0.39	0.25	0.08	0.26	0.23	0.23	0.14	0.33	0.18	0.27	0.02	0.11	0.05	0.14	0.00	0.31	0.30	0.09	0.21	0.40	0.00
9	0.27	0.33	0.28	0.40	0.39	0.27	0.12	0.30	0.28	0.15	0.21	0.29	0.32	0.04	0.30	0.40	0.27	0.27	0.25	0.25	0.27	0.20	0.25	0.16	0.42	0.30	0.27	0.42	0.04
10	0.28	0.35	0.26	0.26	0.21	0.24	0.13	0.36	0.23	0.10	0.11	0.36	0.30	0.21	0.22	0.37	0.26	0.25	0.23	0.24	0.32	0.19	0.23	0.11	0.33	0.30	0.25	0.37	0.10
11	0.30	0.32	0.12	0.27	0.24	0.33	0.08	0.25	0.25	0.13	0.28	0.25	0.04	0.22	0.14	0.30	0.49	0.31	0.39	0.16	0.31	0.13	0.34	0.12	0.43	0.03	0.24	0.49	0.03
12	0.31	0.22	0.22	0.20	0.22	0.26	0.18	0.22	0.29	0.23	0.23	0.26	0.28	0.27	0.25	0.35	0.21	0.09	0.32	0.21	0.40	0.09	0.41	0.27	0.00	0.13	0.24	0.41	0.00
13	0.33	0.31	0.27	0.28	0.24	0.31	0.07	0.30	0.32	0.21	0.05	0.30	0.40	0.28	0.24	0.31	0.35	0.20	0.10	0.30	0.46	0.26	0.26	0.42	0.21	0.20	0.27	0.46	0.05
14	0.31	0.19	0.19	0.28	0.26	0.52	0.18	0.27	0.34	0.20	0.23	0.28	0.28	0.16	0.06	0.28	0.31	0.25	0.13	0.44	0.42	0.32	0.25	0.40	0.30	0.24	0.27	0.52	0.06
15	0.28	0.28	0.30	0.32	0.29	0.22	0.13	0.34	0.28	0.22	0.27	0.32	0.09	0.15	0.19	0.35	0.30	0.30	0.30	0.21	0.31	0.38	0.26	0.26	0.38	0.24	0.27	0.38	0.09
16	0.30	0.34	0.26	0.34	0.23	0.24	0.14	0.21	0.14	0.27	0.28	0.32	0.35	0.11	0.14	0.38	0.30	0.34	0.00	0.32	0.33	0.08	0.38	0.32	0.17	0.20	0.25	0.38	0.00
17	0.30	0.35	0.27	0.27	0.19	0.27	0.25	0.09	0.34	0.30	0.37	0.33	0.31	0.26	0.19	0.33	0.10	0.33	0.10	0.14	0.30	0.16	0.38	0.40	0.25	0.24	0.26	0.40	0.09
18	0.27	0.31	0.26	0.22	0.30	0.32	0.04	0.17	0.34	0.26	0.20	0.39	0.26	0.26	0.23	0.37	0.19	0.36	0.25	0.22	0.31	0.25	0.35	0.27	0.12	0.27	0.26	0.39	0.04
19	0.31	0.02	0.29	0.17	0.13	0.32	0.21	0.18	0.31	0.27	0.32	0.35	0.27	0.27	0.31	0.34	0.19	0.40	0.24	0.28	0.12	0.17	0.32	0.24	0.10	0.25	0.25	0.40	0.02
20	0.34	0.29	0.20	0.22	0.21	0.18	0.35	0.30	0.27	0.32	0.39	0.28	0.30	0.29	0.23	0.38	0.29	0.37	0.05	0.23	0.15	0.27	0.34	0.21	0.11	0.29	0.27	0.39	0.05
21	0.36	0.21	0.25	0.18	0.18	0.14	0.28	0.32	0.30	0.35	0.40	0.18	0.12	0.22	0.25	0.38	0.33	0.19	0.20	0.24	0.28	0.20	0.17	0.26	0.20	0.30	0.25	0.40	0.12
22	0.34	0.27	0.26	0.26	0.29	0.34	0.26	0.33	0.33	0.33	0.41	0.31	0.14	0.29	0.27	0.46	0.15	0.21	0.10	0.27	0.36	0.15	0.19	0.12	0.26	0.31	0.27	0.46	0.10
23	0.24	0.22	0.28	0.21	0.23	0.32	0.33	0.36	0.37	0.35	0.35	0.22	0.20	0.29	0.23	0.29	0.27	0.20	0.12	0.33	0.45	0.16	0.12	0.22	0.27	0.11	0.26	0.45	0.11
24	0.30	0.28	0.27	0.25	0.31	0.26	0.30	0.29	0.28	0.21	0.33	0.34	0.33	0.29	0.36	0.22	0.23	0.28	0.16	0.35	0.23	0.17	0.23	0.26	0.24	0.28	0.27	0.36	0.16
25	0.32	0.24	0.18	0.40	0.31	0.29	0.28	0.09	0.30	0.35	0.31	0.24	0.32	0.30	0.13	0.32	0.25	0.25	0.26	0.25	0.26	0.28	0.18	0.31	0.21	0.00	0.26	0.40	0.00
26	0.32	0.16	0.17	0.29	0.37	0.32	0.41	0.27	0.29	0.37	0.38	0.36	0.06	0.22	0.28	0.21	0.35	0.28	0.29	0.15	0.19	0.23	0.37	0.27	0.09	0.19	0.26	0.41	0.06
27	0.27	0.00	0.26	0.41	0.21	0.30	0.21	0.29	0.27	0.18	0.35	0.27	0.32	0.27	0.12	0.23	0.31	0.00	0.29	0.13	0.18	0.26	0.28	0.39	0.09	0.29	0.24	0.41	0.00
28	0.38	0.32	0.32	0.17	0.32	0.29	0.21	0.27	0.27	0.35	0.23	0.24	0.35	0.28	0.08	0.28	0.15	0.20	0.27	0.18	0.33	0.29	0.37	0.34	0.34	0.33	0.26	0.38	0.04
29	0.26	0.07	0.33	0.21	0.44	0.31	0.28	0.28	0.18	0.32	0.23	0.28	0.25	0.18	0.09	0.33	0.24	0.33	0.30	0.33	0.31	0.31	0.30	0.30	0.25	0.36	0.27	0.44	0.07
30	0.09	0.23	0.28	0.29	0.44	0.10	0.32	0.33	0.24	0.37	0.23	0.32	0.33	0.14	0.28	0.46	0.23	0.09	0.38	0.28	0.32	0.43	0.41	0.42	0.24	0.35	0.29	0.46	0.09
31	0.21	0.30	0.28	0.25	0.38	0.15	0.25	0.39	0.25	0.32	0.32	0.30	0.27	0.28	0.30	0.24	0.27	0.04	0.29	0.21	0.34	0.32	0.28	0.37	0.31	0.12	0.27	0.39	0.04
TOTAL	8.64	7.67	7.55	8.44	8.15	8.11	7.13	7.72	8.55	7.90	8.00	8.48	7.52	6.83	6.58	9.58	7.34	7.04	6.40	7.52	8.51	7.20	7.93	8.31	7.49	6.98	7.75	12.69	1.75

Table 32. Daily evaporation (inches), 1962-1987, Stoneville, June.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.37	0.27	0.10	0.29	0.34	0.14	0.33	0.36	0.21	0.26	0.30	0.24	0.18	0.29	0.24	0.46	0.25	0.24	0.34	0.21	0.32	0.07	0.27	0.36	0.06	0.19	0.26	0.46	0.06
2	0.12	0.36	0.06	0.35	0.37	0.21	0.31	0.36	0.18	0.31	0.28	0.33	0.20	0.26	0.09	0.24	0.08	0.17	0.40	0.21	0.29	0.25	0.38	0.40	0.18	0.30	0.26	0.40	0.06
3	0.21	0.29	0.09	0.27	0.37	0.27	0.24	0.27	0.23	0.27	0.32	0.32	0.28	0.32	0.21	0.40	0.17	0.07	0.43	0.21	0.29	0.30	0.34	0.47	0.24	0.30	0.28	0.47	0.07
4	0.13	0.28	0.25	0.34	0.33	0.28	0.25	0.09	0.22	0.31	0.26	0.19	0.34	0.32	0.22	0.37	0.27	0.20	0.29	0.15	0.28	0.45	0.33	0.36	0.12	0.20	0.26	0.45	0.09
5	0.26	0.30	0.30	0.35	0.31	0.23	0.38	0.28	0.26	0.29	0.29	0.20	0.36	0.25	0.26	0.37	0.25	0.14	0.28	0.15	0.24	0.15	0.38	0.41	0.02	0.34	0.27	0.41	0.02
6	0.25	0.29	0.25	0.30	0.24	0.29	0.29	0.31	0.25	0.29	0.36	0.35	0.21	0.17	0.11	0.53	0.28	0.25	0.37	0.22	0.27	0.28	0.43	0.32	0.23	0.38	0.29	0.53	0.11
7	0.24	0.29	0.29	0.08	0.26	0.29	0.37	0.31	0.27	0.21	0.38	0.39	0.31	0.18	0.35	0.41	0.04	0.28	0.45	0.14	0.33	0.12	0.20	0.30	0.19	0.32	0.27	0.45	0.04
8	0.16	0.30	0.21	0.23	0.26	0.23	0.35	0.33	0.30	0.19	0.28	0.25	0.23	0.22	0.35	0.37	0.23	0.29	0.34	0.16	0.31	0.26	0.23	0.29	0.21	0.37	0.27	0.37	0.16
9	0.22	0.34	0.26	0.19	0.43	0.34	0.33	0.39	0.25	0.26	0.27	0.22	0.30	0.14	0.30	0.33	0.26	0.32	0.34	0.26	0.39	0.28	0.33	0.24	0.17	0.29	0.29	0.43	0.14
10	0.33	0.33	0.34	0.31	0.41	0.32	0.35	0.27	0.29	0.29	0.21	0.21	0.26	0.06	0.25	0.39	0.25	0.38	0.21	0.31	0.32	0.31	0.31	0.38	0.17	0.28	0.29	0.41	0.06
11	0.16	0.29	0.33	0.00	0.34	0.32	0.32	0.35	0.33	0.36	0.29	0.21	0.27	0.15	0.29	0.44	0.36	0.40	0.29	0.24	0.28	0.31	0.36	0.33	0.20	0.19	0.29	0.44	0.00
12	0.32	0.37	0.37	0.00	0.36	0.32	0.36	0.29	0.22	0.40	0.35	0.30	0.23	0.28	0.29	0.30	0.24	0.35	0.40	0.24	0.40	0.26	0.30	0.20	0.00	0.34	0.29	0.40	0.00
13	0.21	0.34	0.31	0.24	0.19	0.30	0.46	0.30	0.24	0.38	0.34	0.18	0.27	0.20	0.35	0.17	0.39	0.31	0.32	0.21	0.08	0.36	0.31	0.31	0.27	0.11	0.28	0.46	0.08
14	0.30	0.37	0.29	0.18	0.24	0.31	0.42	0.40	0.30	0.44	0.36	0.17	0.33	0.18	0.40	0.07	0.36	0.34	0.32	0.35	0.20	0.39	0.19	0.29	0.24	0.13	0.29	0.44	0.07
15	0.26	0.36	0.33	0.29	0.30	0.37	0.38	0.24	0.37	0.33	0.28	0.27	0.17	0.26	0.39	0.29	0.34	0.33	0.49	0.42	0.24	0.53	0.29	0.35	0.33	0.29	0.33	0.53	0.17
16	0.24	0.29	0.30	0.28	0.34	0.38	0.36	0.33	0.36	0.30	0.07	0.32	0.29	0.30	0.34	0.24	0.40	0.28	0.50	0.33	0.42	0.13	0.26	0.28	0.29	0.26	0.30	0.50	0.07
17	0.30	0.21	0.31	0.10	0.35	0.29	0.25	0.29	0.33	0.37	0.14	0.31	0.23	0.29	0.05	0.21	0.39	0.40	0.37	0.34	0.06	0.24	0.23	0.30	0.28	0.16	0.26	0.40	0.05
18	0.30	0.07	0.17	0.17	0.28	0.32	0.38	0.25	0.37	0.38	0.28	0.39	0.12	0.31	0.10	0.29	0.33	0.40	0.28	0.30	0.19	0.17	0.38	0.00	0.34	0.17	0.26	0.40	0.00
19	0.18	0.29	0.32	0.31	0.44	0.34	0.26	0.27	0.38	0.32	0.32	0.19	0.30	0.29	0.08	0.27	0.19	0.37	0.29	0.30	0.26	0.44	0.25	0.06	0.40	0.23	0.28	0.44	0.06
20	0.29	0.27	0.38	0.28	0.36	0.26	0.38	0.08	0.36	0.33	0.35	0.29	0.29	0.32	0.10	0.27	0.28	0.41	0.17	0.29	0.19	0.25	0.34	0.21	0.32	0.23	0.28	0.41	0.08
21	0.27	0.23	0.36	0.30	0.41	0.36	0.17	0.29	0.26	0.23	0.36	0.25	0.35	0.33	0.28	0.32	0.18	0.22	0.08	0.32	0.24	0.24	0.29	0.31	0.32	0.18	0.28	0.41	0.08
22	0.31	0.00	0.34	0.31	0.35	0.33	0.23	0.31	0.28	0.35	0.34	0.31	0.33	0.37	0.26	0.34	0.17	0.14	0.21	0.42	0.08	0.07	0.31	0.25	0.31	0.39	0.27	0.42	0.00
23	0.31	0.00	0.31	0.33	0.27	0.36	0.15	0.20	0.29	0.32	0.28	0.38	0.31	0.30	0.21	0.34	0.31	0.26	0.31	0.31	0.18	0.14	0.35	0.27	0.33	0.26	0.27	0.38	0.00
24	0.31	0.24	0.32	0.12	0.38	0.29	0.18	0.30	0.14	0.25	0.31	0.40	0.33	0.29	0.24	0.41	0.31	0.14	0.26	0.36	0.22	0.25	0.33	0.21	0.25	0.34	0.28	0.41	0.12
25	0.23	0.16	0.31	0.33	0.30	0.41	0.25	0.38	0.25	0.24	0.30	0.37	0.30	0.34	0.26	0.18	0.36	0.18	0.33	0.35	0.21	0.18	0.35	0.30	0.24	0.16	0.28	0.41	0.16
26	0.35	0.29	0.26	0.29	0.32	0.26	0.35	0.30	0.30	0.33	0.09	0.41	0.30	0.30	0.23	0.31	0.41	0.25	0.23	0.09	0.28	0.21	0.34	0.29	0.29	0.27	0.28	0.41	0.09
27	0.15	0.18	0.38	0.30	0.32	0.25	0.21	0.26	0.38	0.30	0.11	0.29	0.37	0.30	0.18	0.40	0.33	0.28	0.29	0.45	0.19	0.18	0.22	0.27	0.32	0.31	0.28	0.45	0.11
28	0.27	0.21	0.18	0.20	0.27	0.33	0.30	0.33	0.34	0.23	0.23	0.48	0.29	0.30	0.30	0.40	0.24	0.28	0.33	0.43	0.22	0.22	0.18	0.27	0.27	0.31	0.29	0.48	0.18
29	0.17	0.26	0.26	0.30	0.36	0.40	0.35	0.35	0.37	0.14	0.25	0.46	0.30	0.25	0.34	0.30	0.25	0.30	0.35	0.32	0.14	0.26	0.35	0.27	0.13	0.31	0.29	0.46	0.13
30	0.25	0.26	0.18	0.21	0.26	0.27	0.33	0.37	0.34	0.23	0.20	0.27	0.36	0.38	0.42	0.32	0.41	0.28	0.27	0.29	0.21	0.28	0.09	0.34	0.26	0.37	0.29	0.42	0.09
TOTAL	7.47	7.74	8.16	7.25	9.75	9.07	9.29	8.86	8.67	8.91	8.20	8.96	8.41	7.95	7.48	9.74	8.33	8.26	9.54	8.38	7.33	7.58	8.92	8.64	6.98	7.98	8.41	13.05	2.35

Table 33. Daily evaporation (inches), 1962-1987, Stoneville, July.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.22	0.24	0.00	0.30	0.35	0.31	0.35	0.31	0.35	0.33	0.30	0.28	0.30	0.30	0.31	0.32	0.29	0.16	0.34	0.27	0.35	0.27	0.27	0.26	0.30	0.32	0.26	0.35	0.00
2	0.32	0.32	0.32	0.35	0.11	0.14	0.38	0.27	0.36	0.24	0.25	0.30	0.39	0.35	0.12	0.36	0.35	0.39	0.30	0.10	0.24	0.32	0.39	0.24	0.29	0.32	0.28	0.39	0.02
3	0.26	0.34	0.35	0.38	0.24	0.29	0.32	0.34	0.40	0.28	0.25	0.35	0.35	0.27	0.33	0.31	0.25	0.07	0.32	0.13	0.31	0.29	0.24	0.14	0.17	0.26	0.28	0.40	0.13
4	0.31	0.31	0.18	0.39	0.25	0.25	0.26	0.39	0.31	0.28	0.24	0.32	0.33	0.28	0.27	0.31	0.35	0.34	0.41	0.22	0.33	0.35	0.30	0.22	0.28	0.19	0.29	0.41	0.18
5	0.33	0.30	0.13	0.10	0.27	0.17	0.39	0.20	0.35	0.29	0.27	0.25	0.25	0.25	0.02	0.31	0.34	0.27	0.35	0.19	0.29	0.29	0.39	0.22	0.35	0.37	0.27	0.39	0.00
6	0.31	0.28	0.25	0.25	0.33	0.08	0.33	0.30	0.33	0.27	0.27	0.20	0.27	0.36	0.22	0.25	0.30	0.36	0.35	0.19	0.24	0.19	0.32	0.33	0.36	0.32	0.27	0.39	0.06
7	0.34	0.33	0.29	0.25	0.28	0.18	0.26	0.30	0.34	0.35	0.27	0.29	0.30	0.35	0.24	0.39	0.32	0.15	0.30	0.09	0.31	0.22	0.32	0.30	0.33	0.19	0.27	0.39	0.09
8	0.37	0.39	0.32	0.30	0.35	0.33	0.24	0.37	0.14	0.33	0.24	0.10	0.24	0.32	0.33	0.30	0.27	0.12	0.35	0.23	0.23	0.30	0.29	0.29	0.33	0.33	0.24	0.37	0.10
9	0.34	0.32	0.28	0.25	0.38	0.14	0.28	0.27	0.33	0.28	0.33	0.31	0.35	0.40	0.23	0.20	0.33	0.21	0.34	0.23	0.21	0.24	0.38	0.22	0.32	0.27	0.27	0.38	0.14
10	0.34	0.24	0.44	0.21	0.21	0.25	0.23	0.40	0.30	0.37	0.32	0.45	0.36	0.21	0.23	0.32	0.38	0.23	0.33	0.24	0.33	0.29	0.33	0.33	0.34	0.11	0.30	0.45	0.12
11	0.21	0.32	0.23	0.24	0.35	0.30	0.32	0.35	0.26	0.31	0.27	0.39	0.33	0.32	0.25	0.19	0.22	0.15	0.33	0.26	0.31	0.25	0.38	0.31	0.32	0.31	0.29	0.39	0.15
12	0.36	0.31	0.17	0.30	0.32	0.12	0.21	0.34	0.30	0.36	0.29	0.38	0.25	0.33	0.25	0.27	0.30	0.23	0.33	0.37	0.12	0.34	0.27	0.35	0.33	0.27	0.29	0.38	0.12
13	0.37	0.22	0.13	0.30	0.35	0.20	0.21	0.33	0.36	0.32	0.33	0.32	0.24	0.33	0.22	0.26	0.36	0.22	0.32	0.30	0.28	0.23	0.30	0.34	0.22	0.29	0.29	0.33	0.13
14	0.34	0.30	0.16	0.24	0.36	0.30	0.22	0.31	0.27	0.39	0.24	0.29	0.38	0.33	0.30	0.23	0.31	0.33	0.37	0.32	0.27	0.23	0.16	0.33	0.28	0.30	0.27	0.39	0.00
15	0.34	0.00	0.21	0.27	0.34	0.32	0.29	0.36	0.32	0.42	0.33	0.27	0.27	0.23	0.30	0.35	0.31	0.09	0.37	0.23	0.30	0.31	0.25	0.31	0.34	0.25	0.28	0.42	0.00
16	0.22	0.00	0.35	0.16	0.23	0.12	0.24	0.34	0.28	0.49	0.25	0.16	0.35	0.23	0.27	0.22	0.34	0.24	0.36	0.24	0.28	0.35	0.26	0.32	0.33	0.23	0.28	0.49	0.00
17	0.31	0.30	0.27	0.25	0.31	0.27	0.25	0.33	0.23	0.21	0.23	0.16	0.36	0.32	0.19	0.32	0.26	0.30	0.41	0.30	0.28	0.16	0.12	0.16	0.31	0.25	0.25	0.41	0.02
18	0.37	0.15	0.21	0.33	0.34	0.21	0.23	0.08	0.24	0.32	0.28	0.25	0.16	0.31	0.23	0.27	0.30	0.30	0.34	0.28	0.29	0.22	0.15	0.31	0.29	0.23	0.26	0.37	0.08
19	0.35	0.17	0.22	0.26	0.33	0.12	0.27	0.09	0.16	0.44	0.07	0.30	0.24	0.32	0.23	0.17	0.27	0.16	0.43	0.22	0.23	0.26	0.34	0.34	0.23	0.30	0.22	0.45	0.09
20	0.31	0.29	0.26	0.28	0.14	0.18	0.22	0.29	0.27	0.17	0.32	0.33	0.30	0.31	0.23	0.23	0.36	0.15	0.29	0.34	0.35	0.20	0.32	0.24	0.30	0.32	0.27	0.36	0.13
21	0.28	0.40	0.27	0.35	0.30	0.28	0.34	0.35	0.05	0.28	0.33	0.30	0.31	0.30	0.27	0.34	0.34	0.22	0.19	0.34	0.22	0.24	0.37	0.25	0.22	0.33	0.28	0.40	0.05
22	0.22	0.35	0.22	0.30	0.32	0.37	0.21	0.22	0.04	0.30	0.24	0.33	0.31	0.27	0.19	0.19	0.32	0.33	0.42	0.23	0.27	0.33	0.29	0.19	0.33	0.28	0.26	0.36	0.04
23	0.23	0.35	0.26	0.20	0.24	0.12	0.10	0.24	0.19	0.23	0.27	0.28	0.19	0.29	0.27	0.20	0.33	0.27	0.21	0.26	0.33	0.15	0.32	0.02	0.23	0.11	0.23	0.33	0.02
24	0.33	0.18	0.19	0.37	0.27	0.23	0.14	0.27	0.30	0.23	0.25	0.36	0.10	0.19	0.30	0.27	0.33	0.12	0.27	0.26	0.27	0.31	0.15	0.14	0.33	0.13	0.24	0.36	0.10
25	0.14	0.27	0.19	0.19	0.30	0.31	0.17	0.07	0.16	0.32	0.40	0.34	0.16	0.12	0.23	0.31	0.32	0.00	0.32	0.35	0.16	0.34	0.31	0.19	0.29	0.20	0.25	0.40	0.00
26	0.19	0.12	0.25	0.19	0.32	0.26	0.36	0.13	0.32	0.10	0.30	0.17	0.12	0.19	0.34	0.17	0.37	0.19	0.26	0.32	0.11	0.26	0.29	0.31	0.32	0.19	0.25	0.37	0.10
27	0.20	0.30	0.26	0.12	0.31	0.36	0.29	0.32	0.21	0.13	0.30	0.30	0.27	0.23	0.22	0.19	0.32	0.33	0.35	0.22	0.17	0.12	0.29	0.19	0.34	0.26	0.24	0.36	0.12
28	0.12	0.22	0.19	0.19	0.35	0.31	0.30	0.25	0.38	0.11	0.25	0.33	0.26	0.23	0.24	0.16	0.22	0.18	0.12	0.30	0.27	0.32	0.09	0.23	0.25	0.21	0.23	0.35	0.09
29	0.19	0.26	0.22	0.22	0.33	0.17	0.33	0.31	0.38	0.08	0.23	0.31	0.33	0.30	0.29	0.19	0.34	0.07	0.24	0.24	0.27	0.32	0.19	0.28	0.34	0.17	0.26	0.39	0.08
30	0.35	0.29	0.26	0.19	0.23	0.32	0.15	0.30	0.29	0.16	0.12	0.27	0.25	0.10	0.33	0.16	0.39	0.32	0.23	0.14	0.23	0.24	0.39	0.26	0.33	0.15	0.25	0.39	0.12
31	0.39	0.14	0.15	0.23	0.28	0.26	0.15	0.28	0.33	0.28	0.27	0.10	0.14	0.27	0.34	0.08	0.23	0.30	0.31	0.25	0.29	0.31	0.31	0.31	0.39	0.22	0.24	0.39	0.07
TOTAL	8.95	8.80	8.72	9.42	9.07	7.11	9.97	8.67	8.33	8.36	8.35	8.59	8.67	9.13	7.92	8.95	9.35	7.13	9.52	7.79	8.87	7.95	8.34	7.53	9.07	7.23	8.10	10.09	3.29

Table 34. Daily evaporation (inches), 1962-1987, Stoneville, August.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.27	0.14	0.17	0.27	0.29	0.15	0.25	0.29	0.32	0.26	0.21	0.24	0.21	0.06	0.22	0.25	0.32	0.27	0.34	0.27	0.16	0.35	0.21	0.32	0.44	0.27	0.25	0.44	0.06
2	0.13	0.27	0.24	0.25	0.07	0.14	0.33	0.34	0.26	0.09	0.26	0.28	0.28	0.16	0.29	0.31	0.27	0.17	0.25	0.20	0.04	0.26	0.24	0.28	0.30	0.28	0.23	0.34	0.04
3	0.11	0.26	0.17	0.31	0.17	0.22	0.35	0.38	0.30	0.14	0.33	0.27	0.26	0.26	0.29	0.26	0.33	0.12	0.33	0.26	0.18	0.14	0.14	0.28	0.12	0.28	0.24	0.38	0.11
4	0.27	0.29	0.22	0.23	0.24	0.21	0.22	0.31	0.27	0.21	0.28	0.24	0.27	0.15	0.35	0.19	0.24	0.13	0.29	0.25	0.23	0.24	0.15	0.25	0.33	0.34	0.25	0.35	0.13
5	0.30	0.22	0.25	0.21	0.15	0.26	0.29	0.28	0.30	0.21	0.32	0.24	0.31	0.22	0.20	0.33	0.24	0.17	0.36	0.23	0.23	0.21	0.02	0.27	0.30	0.30	0.25	0.36	0.02
6	0.33	0.23	0.36	0.19	0.41	0.25	0.25	0.30	0.22	0.20	0.24	0.22	0.28	0.31	0.22	0.27	0.29	0.30	0.28	0.25	0.24	0.00	0.22	0.21	0.27	0.20	0.25	0.41	0.00
7	0.35	0.25	0.28	0.25	0.27	0.25	0.28	0.26	0.19	0.23	0.37	0.27	0.14	0.10	0.31	0.31	0.28	0.26	0.27	0.31	0.14	0.27	0.20	0.05	0.27	0.27	0.25	0.37	0.05
8	0.39	0.27	0.26	0.27	0.30	0.27	0.15	0.31	0.06	0.20	0.30	0.27	0.18	0.21	0.32	0.29	0.28	0.20	0.29	0.16	0.20	0.21	0.13	0.16	0.28	0.31	0.24	0.39	0.06
9	0.37	0.28	0.23	0.35	0.24	0.30	0.20	0.35	0.33	0.13	0.32	0.28	0.23	0.21	0.27	0.33	0.20	0.27	0.29	0.29	0.24	0.24	0.18	0.27	0.11	0.28	0.26	0.37	0.11
10	0.33	0.22	0.20	0.27	0.30	0.15	0.25	0.38	0.04	0.12	0.23	0.30	0.24	0.23	0.30	0.35	0.03	0.22	0.28	0.25	0.22	0.31	0.20	0.27	0.27	0.33	0.24	0.38	0.03
11	0.39	0.27	0.26	0.28	0.13	0.33	0.23	0.35	0.13	0.30	0.18	0.28	0.23	0.21	0.25	0.23	0.33	0.27	0.20	0.27	0.25	0.27	0.03	0.26	0.24	0.10	0.24	0.39	0.03
12	0.36	0.19	0.20	0.25	0.19	0.38	0.15	0.34	0.21	0.23	0.30	0.30	0.29	0.21	0.27	0.22	0.25	0.19	0.19	0.30	0.22	0.32	0.20	0.28	0.34	0.12	0.25	0.38	0.12
13	0.37	0.13	0.23	0.21	0.24	0.28	0.27	0.31	0.22	0.18	0.26	0.28	0.19	0.18	0.26	0.27	0.17	0.19	0.22	0.30	0.10	0.12	0.17	0.29	0.34	0.24	0.23	0.37	0.10
14	0.40	0.29	0.19	0.09	0.21	0.22	0.18	0.31	0.25	0.26	0.11	0.17	0.23	0.23	0.25	0.27	0.26	0.19	0.26	0.27	0.31	0.19	0.12	0.28	0.25	0.24	0.23	0.40	0.09
15	0.31	0.23	0.24	0.19	0.38	0.23	0.10	0.25	0.25	0.29	0.25	0.32	0.19	0.25	0.33	0.26	0.22	0.24	0.28	0.30	0.13	0.23	0.17	0.22	0.25	0.14	0.24	0.38	0.10
16	0.32	0.27	0.31	0.26	0.16	0.29	0.21	0.29	0.23	0.29	0.32	0.18	0.13	0.16	0.28	0.32	0.31	0.25	0.33	0.26	0.25	0.24	0.12	0.22	0.29	0.26	0.25	0.33	0.12
17	0.37	0.22	0.00	0.26	0.31	0.16	0.25	0.39	0.26	0.25	0.15	0.14	0.24	0.20	0.28	0.16	0.30	0.18	0.31	0.29	0.21	0.20	0.20	0.09	0.14	0.31	0.23	0.39	0.00
18	0.31	0.23	0.14	0.27	0.28	0.08	0.23	0.03	0.24	0.25	0.21	0.16	0.27	0.08	0.33	0.11	0.32	0.18	0.31	0.15	0.16	0.27	0.20	0.20	0.29	0.26	0.21	0.33	0.03
19	0.32	0.25	0.15	0.17	0.22	0.15	0.27	0.22	0.26	0.23	0.24	0.22	0.21	0.16	0.30	0.28	0.27	0.24	0.32	0.14	0.21	0.28	0.21	0.21	0.36	0.21	0.23	0.36	0.14
20	0.28	0.25	0.15	0.22	0.11	0.15	0.30	0.28	0.25	0.23	0.25	0.30	0.29	0.22	0.29	0.26	0.35	0.23	0.32	0.16	0.25	0.23	0.12	0.32	0.33	0.22	0.24	0.35	0.11
21	0.29	0.16	0.24	0.12	0.19	0.15	0.12	0.20	0.13	0.24	0.26	0.40	0.25	0.24	0.28	0.22	0.29	0.26	0.31	0.15	0.19	0.22	0.20	0.15	0.31	0.21	0.22	0.40	0.12
22	0.27	0.22	0.21	0.19	0.29	0.28	0.23	0.21	0.30	0.24	0.29	0.27	0.24	0.20	0.25	0.20	0.28	0.28	0.28	0.19	0.22	0.29	0.23	0.17	0.23	0.29	0.24	0.30	0.17
23	0.24	0.27	0.27	0.14	0.30	0.19	0.30	0.10	0.07	0.09	0.29	0.28	0.28	0.24	0.22	0.21	0.24	0.14	0.36	0.15	0.25	0.27	0.15	0.20	0.32	0.25	0.22	0.36	0.07
24	0.24	0.29	0.23	0.12	0.27	0.15	0.24	0.18	0.24	0.22	0.26	0.28	0.28	0.26	0.23	0.19	0.28	0.23	0.33	0.21	0.26	0.26	0.25	0.24	0.29	0.30	0.24	0.33	0.12
25	0.17	0.23	0.15	0.00	0.25	0.10	0.34	0.25	0.25	0.19	0.22	0.29	0.29	0.29	0.19	0.21	0.24	0.07	0.25	0.19	0.33	0.26	0.24	0.19	0.27	0.27	0.22	0.34	0.00
26	0.19	0.20	0.18	0.32	0.27	0.20	0.16	0.26	0.25	0.24	0.27	0.28	0.17	0.21	0.27	0.26	0.28	0.16	0.28	0.26	0.25	0.23	0.24	0.28	0.28	0.31	0.24	0.32	0.16
27	0.26	0.26	0.19	0.23	0.29	0.16	0.39	0.20	0.23	0.28	0.27	0.28	0.23	0.18	0.25	0.25	0.32	0.22	0.22	0.18	0.31	0.22	0.21	0.19	0.25	0.29	0.24	0.39	0.16
28	0.26	0.22	0.24	0.34	0.30	0.21	0.33	0.28	0.15	0.26	0.25	0.28	0.19	0.21	0.20	0.25	0.18	0.18	0.23	0.12	0.20	0.28	0.22	0.18	0.21	0.21	0.23	0.34	0.12
29	0.09	0.25	0.28	0.19	0.28	0.25	0.26	0.31	0.23	0.29	0.28	0.07	0.11	0.20	0.12	0.25	0.09	0.24	0.03	0.14	0.19	0.26	0.21	0.24	0.30	0.18	0.21	0.31	0.03
30	0.18	0.23	0.17	0.22	0.30	0.22	0.24	0.29	0.19	0.20	0.27	0.23	0.07	0.19	0.24	0.26	0.11	0.23	0.20	0.22	0.21	0.28	0.19	0.23	0.24	0.25	0.22	0.30	0.07
31	0.25	0.20	0.21	0.24	0.23	0.15	0.24	0.15	0.21	0.22	0.25	0.27	0.21	0.20	0.21	0.28	0.18	0.24	0.28	0.28	0.20	0.28	0.12	0.24	0.24	0.11	0.22	0.28	0.11
TOTAL	8.72	7.29	6.62	6.91	7.64	6.53	7.61	8.40	6.84	6.77	8.04	7.89	6.99	6.23	8.07	7.85	7.75	6.52	8.49	7.00	6.58	7.43	5.49	7.04	8.46	7.63	7.31	11.14	2.58

Table 35. Daily evaporation (inches), 1962-1987, Stoneville, September.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.21	0.35	0.26	0.24	0.23	0.27	0.28	0.21	0.21	0.09	0.28	0.23	0.21	0.23	0.17	0.29	0.14	0.16	0.29	0.14	0.20	0.10	0.15	0.27	0.19	0.15	0.21	0.35	0.09
2	0.25	0.27	0.26	0.26	0.18	0.19	0.23	0.09	0.14	0.19	0.26	0.04	0.15	0.25	0.17	0.30	0.10	0.00	0.31	0.13	0.27	0.25	0.23	0.32	0.15	0.35	0.21	0.35	0.02
3	0.28	0.26	0.34	0.20	0.23	0.14	0.15	0.12	0.25	0.24	0.25	0.11	0.10	0.30	0.11	0.31	0.12	0.22	0.33	0.15	0.25	0.23	0.27	0.36	0.05	0.27	0.22	0.36	0.05
4	0.23	0.22	0.28	0.08	0.16	0.06	0.10	0.16	0.22	0.20	0.18	0.15	0.21	0.27	0.10	0.23	0.23	0.29	0.22	0.10	0.28	0.34	0.25	0.12	0.21	0.28	0.20	0.29	0.06
5	0.22	0.12	0.25	0.05	0.25	0.13	0.12	0.21	0.20	0.12	0.09	0.03	0.20	0.09	0.10	0.25	0.26	0.13	0.30	0.23	0.29	0.22	0.30	0.27	0.16	0.30	0.19	0.30	0.03
6	0.23	0.21	0.25	0.13	0.29	0.05	0.11	0.15	0.25	0.21	0.25	0.05	0.04	0.30	0.24	0.12	0.18	0.20	0.24	0.22	0.22	0.23	0.19	0.21	0.12	0.26	0.19	0.29	0.04
7	0.13	0.24	0.22	0.22	0.30	0.01	0.24	0.18	0.22	0.26	0.18	0.11	0.08	0.32	0.33	0.25	0.21	0.17	0.25	0.20	0.18	0.18	0.23	0.22	0.13	0.23	0.20	0.32	0.01
8	0.15	0.19	0.24	0.24	0.23	0.18	0.18	0.25	0.27	0.26	0.22	0.19	0.16	0.17	0.16	0.20	0.20	0.22	0.22	0.18	0.29	0.27	0.28	0.22	0.28	0.25	0.22	0.29	0.15
9	0.19	0.25	0.28	0.29	0.23	0.19	0.40	0.22	0.26	0.26	0.23	0.25	0.21	0.25	0.11	0.21	0.15	0.26	0.23	0.22	0.26	0.25	0.25	0.22	0.32	0.21	0.24	0.40	0.11
10	0.18	0.25	0.21	0.28	0.12	0.20	0.19	0.23	0.31	0.25	0.27	0.28	0.18	0.26	0.23	0.22	0.25	0.22	0.22	0.21	0.26	0.22	0.17	0.16	0.23	0.20	0.22	0.31	0.11
11	0.16	0.27	0.27	0.22	0.06	0.18	0.20	0.21	0.13	0.22	0.25	0.22	0.22	0.20	0.07	0.23	0.10	0.21	0.31	0.21	0.15	0.21	0.22	0.19	0.25	0.17	0.20	0.31	0.06
12	0.21	0.28	0.25	0.23	0.17	0.11	0.19	0.22	0.30	0.27	0.20	0.17	0.16	0.15	0.31	0.23	0.02	0.23	0.26	0.21	0.25	0.29	0.17	0.16	0.29	0.04	0.21	0.31	0.04
13	0.22	0.23	0.00	0.19	0.20	0.17	0.20	0.23	0.25	0.27	0.19	0.18	0.02	0.25	0.24	0.15	0.12	0.24	0.24	0.20	0.11	0.05	0.25	0.23	0.26	0.21	0.19	0.27	0.00
14	0.10	0.15	0.00	0.26	0.19	0.14	0.20	0.17	0.26	0.25	0.23	0.18	0.11	0.17	0.26	0.13	0.09	0.11	0.24	0.13	0.20	0.25	0.21	0.26	0.25	0.17	0.18	0.26	0.00
15	0.05	0.03	0.29	0.21	0.15	0.12	0.19	0.23	0.27	0.24	0.23	0.18	0.20	0.13	0.19	0.07	0.09	0.24	0.29	0.10	0.19	0.27	0.22	0.11	0.20	0.19	0.18	0.29	0.03
16	0.17	0.09	0.22	0.21	0.07	0.22	0.09	0.22	0.24	0.08	0.31	0.17	0.20	0.03	0.21	0.10	0.18	0.25	0.29	0.29	0.24	0.26	0.30	0.22	0.17	0.25	0.23	0.31	0.03
17	0.19	0.13	0.24	0.27	0.13	0.24	0.14	0.20	0.22	0.24	0.23	0.27	0.10	0.14	0.19	0.16	0.19	0.21	0.35	0.27	0.16	0.22	0.22	0.25	0.12	0.24	0.21	0.35	0.10
18	0.25	0.15	0.26	0.24	0.15	0.24	0.16	0.25	0.23	0.19	0.06	0.22	0.19	0.19	0.13	0.22	0.21	0.06	0.15	0.19	0.12	0.27	0.21	0.26	0.22	0.23	0.20	0.28	0.06
19	0.23	0.24	0.08	0.19	0.17	0.16	0.19	0.19	0.36	0.06	0.18	0.15	0.19	0.24	0.19	0.20	0.22	0.05	0.21	0.21	0.23	0.31	0.23	0.16	0.26	0.08	0.19	0.36	0.05
20	0.29	0.16	0.04	0.17	0.11	0.19	0.18	0.15	0.13	0.08	0.20	0.15	0.20	0.22	0.19	0.21	0.20	0.05	0.25	0.13	0.22	0.03	0.25	0.22	0.21	0.15	0.17	0.29	0.03
21	0.12	0.36	0.16	0.20	0.17	0.15	0.19	0.10	0.21	0.11	0.19	0.20	0.11	0.26	0.09	0.20	0.20	0.00	0.17	0.18	0.12	0.19	0.24	0.24	0.16	0.23	0.18	0.36	0.00
22	0.18	0.25	0.23	0.13	0.20	0.27	0.17	0.12	0.25	0.09	0.25	0.19	0.21	0.08	0.24	0.18	0.16	0.03	0.20	0.19	0.20	0.19	0.26	0.21	0.17	0.19	0.19	0.27	0.03
23	0.20	0.38	0.22	0.00	0.19	0.23	0.21	0.15	0.09	0.16	0.17	0.18	0.19	0.23	0.21	0.20	0.23	0.15	0.33	0.16	0.18	0.13	0.16	0.23	0.03	0.19	0.18	0.38	0.00
24	0.18	0.31	0.24	0.03	0.18	0.21	0.20	0.24	0.12	0.09	0.17	0.17	0.12	0.19	0.24	0.28	0.21	0.24	0.21	0.23	0.17	0.19	0.10	0.19	0.23	0.20	0.19	0.31	0.03
25	0.17	0.24	0.22	0.23	0.18	0.20	0.17	0.21	0.10	0.14	0.18	0.24	0.19	0.19	0.15	0.25	0.23	0.16	0.09	0.19	0.18	0.17	0.27	0.27	0.26	0.20	0.19	0.27	0.09
26	0.16	0.19	0.30	0.17	0.22	0.22	0.16	0.24	0.15	0.13	0.11	0.22	0.01	0.20	0.15	0.23	0.15	0.21	0.08	0.21	0.17	0.14	0.27	0.12	0.27	0.19	0.18	0.30	0.01
27	0.17	0.06	0.25	0.12	0.14	0.01	0.20	0.22	0.14	0.15	0.12	0.12	0.08	0.19	0.17	0.13	0.07	0.19	0.22	0.16	0.03	0.15	0.15	0.19	0.28	0.20	0.15	0.22	0.01
28	0.20	0.03	0.23	0.19	0.14	0.18	0.19	0.30	0.22	0.18	0.13	0.10	0.25	0.16	0.30	0.07	0.08	0.13	0.06	0.17	0.14	0.17	0.18	0.18	0.26	0.24	0.17	0.30	0.03
29	0.19	0.11	0.00	0.17	0.15	0.15	0.20	0.25	0.19	0.20	0.16	0.17	0.21	0.17	0.06	0.07	0.10	0.15	0.08	0.24	0.20	0.19	0.16	0.18	0.29	0.20	0.16	0.29	0.00
30	0.17	0.09	0.02	0.14	0.20	0.16	0.23	0.10	0.20	0.13	0.21	0.16	0.16	0.17	0.11	0.21	0.18	0.13	0.06	0.20	0.31	0.23	0.17	0.25	0.33	0.21	0.17	0.33	0.02
TOTAL	5.74	6.12	6.11	5.61	5.45	4.97	5.73	5.83	6.40	5.50	5.99	5.09	4.66	5.90	5.28	6.52	4.93	4.97	6.74	5.65	5.97	6.09	6.46	6.47	6.37	6.28	5.79	9.38	1.27

Table 36. Daily evaporation (inches), 1962-1987, Stoneville, October.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.15	0.21	0.08	0.00	0.14	0.15	0.14	0.17	0.17	0.19	0.19	0.18	0.19	0.24	0.14	0.29	0.21	0.18	0.08	0.11	0.18	0.13	0.18	0.06	0.24	0.24	0.16	0.29	0.00
2	0.19	0.15	0.12	0.11	0.16	0.17	0.17	0.18	0.22	0.17	0.17	0.13	0.20	0.24	0.23	0.19	0.15	0.23	0.12	0.06	0.21	0.25	0.18	0.19	0.17	0.20	0.18	0.25	0.06
3	0.15	0.15	0.12	0.15	0.18	0.14	0.17	0.15	0.30	0.18	0.19	0.16	0.16	0.19	0.22	0.21	0.21	0.20	0.20	0.01	0.15	0.28	0.16	0.18	0.17	0.35	0.18	0.35	0.01
4	0.18	0.25	0.04	0.18	0.25	0.16	0.13	0.21	0.21	0.18	0.13	0.24	0.17	0.12	0.18	0.15	0.24	0.30	0.18	0.07	0.20	0.21	0.22	0.09	0.25	0.24	0.18	0.30	0.04
5	0.17	0.26	0.08	0.14	0.14	0.20	0.22	0.22	0.22	0.05	0.14	0.18	0.18	0.08	0.24	0.16	0.17	0.20	0.22	0.09	0.19	0.21	0.18	0.21	0.25	0.16	0.18	0.26	0.05
6	0.19	0.21	0.31	0.12	0.20	0.19	0.21	0.15	0.05	0.21	0.21	0.17	0.19	0.03	0.17	0.19	0.12	0.20	0.20	0.13	0.21	0.16	0.09	0.16	0.11	0.24	0.17	0.31	0.03
7	0.27	0.21	0.26	0.05	0.14	0.21	0.10	0.12	0.08	0.17	0.17	0.10	0.15	0.11	0.14	0.31	0.16	0.18	0.15	0.15	0.00	0.22	0.00	0.14	0.06	0.28	0.15	0.31	0.00
8	0.04	0.19	0.18	0.18	0.13	0.14	0.07	0.21	0.22	0.23	0.17	0.14	0.11	0.17	0.10	0.14	0.16	0.20	0.15	0.09	0.02	0.28	0.04	0.24	0.19	0.19	0.15	0.28	0.02
9	0.13	0.22	0.14	0.27	0.16	0.16	0.05	0.15	0.12	0.18	0.16	0.18	0.15	0.17	0.02	0.17	0.18	0.28	0.20	0.12	0.10	0.20	0.08	0.20	0.02	0.20	0.15	0.28	0.02
10	0.17	0.28	0.19	0.21	0.33	0.19	0.15	0.12	0.13	0.20	0.21	0.23	0.15	0.16	0.04	0.10	0.19	0.08	0.19	0.18	0.14	0.18	0.14	0.21	0.07	0.19	0.17	0.33	0.04
11	0.18	0.21	0.17	0.20	0.15	0.14	0.06	0.19	0.18	0.16	0.21	0.18	0.14	0.19	0.12	0.10	0.18	0.14	0.20	0.13	0.14	0.20	0.11	0.17	0.19	0.20	0.16	0.21	0.06
12	0.15	0.23	0.20	0.15	0.28	0.13	0.05	0.18	0.10	0.17	0.18	0.14	0.16	0.19	0.15	0.13	0.21	0.23	0.25	0.09	0.10	0.09	0.10	0.19	0.15	0.20	0.16	0.28	0.05
13	0.16	0.22	0.15	0.14	0.06	0.16	0.11	0.15	0.14	0.09	0.17	0.06	0.12	0.21	0.15	0.13	0.08	0.25	0.16	0.06	0.03	0.07	0.07	0.18	0.00	0.21	0.13	0.25	0.00
14	0.13	0.25	0.15	0.09	0.28	0.20	0.08	0.10	0.09	0.12	0.19	0.04	0.22	0.19	0.15	0.13	0.15	0.26	0.16	0.08	0.15	0.16	0.15	0.16	0.09	0.16	0.15	0.28	0.04
15	0.16	0.22	0.12	0.19	0.17	0.22	0.15	0.08	0.14	0.16	0.24	0.07	0.03	0.11	0.16	0.18	0.17	0.16	0.18	0.09	0.13	0.17	0.12	0.12	0.06	0.19	0.15	0.24	0.03
16	0.12	0.21	0.02	0.17	0.14	0.06	0.19	0.20	0.15	0.09	0.16	0.14	0.12	0.06	0.04	0.15	0.21	0.21	0.19	0.11	0.15	0.15	0.13	0.07	0.13	0.18	0.14	0.21	0.02
17	0.12	0.17	0.03	0.15	0.14	0.05	0.15	0.22	0.09	0.12	0.17	0.18	0.14	0.17	0.04	0.22	0.15	0.13	0.16	0.10	0.19	0.04	0.18	0.11	0.14	0.15	0.14	0.22	0.03
18	0.19	0.20	0.17	0.18	0.03	0.20	0.18	0.17	0.05	0.14	0.18	0.16	0.19	0.15	0.11	0.14	0.14	0.13	0.07	0.09	0.09	0.12	0.07	0.12	0.17	0.18	0.14	0.20	0.03
19	0.14	0.21	0.18	0.22	0.07	0.10	0.15	0.15	0.03	0.14	0.27	0.16	0.17	0.15	0.12	0.17	0.16	0.18	0.08	0.22	0.13	0.09	0.11	0.13	0.14	0.09	0.14	0.27	0.03
20	0.25	0.19	0.21	0.06	0.08	0.14	0.12	0.09	0.04	0.11	0.08	0.14	0.16	0.16	0.10	0.15	0.17	0.22	0.14	0.13	0.18	0.16	0.08	0.10	0.14	0.04	0.13	0.25	0.04
21	0.13	0.18	0.19	0.08	0.12	0.13	0.12	0.22	0.03	0.09	0.13	0.17	0.12	0.16	0.10	0.13	0.19	0.24	0.08	0.14	0.12	0.20	0.34	0.07	0.14	0.11	0.14	0.34	0.03
22	0.12	0.19	0.18	0.25	0.08	0.15	0.12	0.33	0.12	0.12	0.17	0.15	0.12	0.15	0.11	0.17	0.18	0.25	0.13	0.15	0.14	0.08	0.11	0.10	0.14	0.16	0.15	0.33	0.08
23	0.20	0.18	0.16	0.06	0.12	0.15	0.15	0.18	0.10	0.07	0.03	0.15	0.11	0.13	0.16	0.06	0.19	0.10	0.17	0.07	0.12	0.17	0.01	0.03	0.12	0.15	0.12	0.20	0.01
24	0.07	0.17	0.22	0.27	0.11	0.24	0.13	0.12	0.07	0.11	0.17	0.18	0.12	0.14	0.19	0.14	0.14	0.13	0.16	0.14	0.14	0.05	0.03	0.09	0.12	0.18	0.14	0.27	0.03
25	0.14	0.08	0.19	0.15	0.19	0.18	0.18	0.14	0.09	0.11	0.13	0.13	0.12	0.02	0.00	0.05	0.19	0.12	0.14	0.13	0.12	0.07	0.01	0.12	0.00	0.09	0.11	0.19	0.00
26	0.10	0.07	0.14	0.14	0.15	0.21	0.12	0.13	0.16	0.12	0.07	0.17	0.12	0.07	0.12	0.15	0.09	0.12	0.12	0.17	0.12	0.14	0.08	0.29	0.10	0.02	0.13	0.29	0.02
27	0.12	0.13	0.18	0.13	0.12	0.22	0.10	0.26	0.03	0.15	0.11	0.16	0.12	0.04	0.15	0.11	0.13	0.14	0.13	0.07	0.09	0.09	0.14	0.02	0.05	0.08	0.12	0.26	0.02
28	0.09	0.17	0.18	0.18	0.11	0.13	0.17	0.17	0.03	0.13	0.09	0.11	0.07	0.09	0.12	0.04	0.19	0.20	0.12	0.08	0.14	0.14	0.13	0.12	0.09	0.21	0.13	0.21	0.03
29	0.04	0.22	0.09	0.20	0.16	0.18	0.14	0.13	0.13	0.14	0.11	0.10	0.07	0.19	0.11	0.13	0.17	0.09	0.09	0.02	0.15	0.12	0.07	0.03	0.12	0.14	0.12	0.22	0.02
30	0.10	0.19	0.02	0.15	0.10	0.03	0.09	0.10	0.09	0.13	0.04	0.12	0.10	0.16	0.03	0.15	0.14	0.09	0.06	0.11	0.03	0.11	0.11	0.09	0.11	0.19	0.10	0.19	0.02
31	0.08	0.18	0.11	0.09	0.16	0.08	0.09	0.08	0.08	0.15	0.02	0.08	0.08	0.12	0.06	0.12	0.13	0.00	0.09	0.06	0.10	0.12	0.11	0.04	0.15	0.20	0.10	0.20	0.00
TOTAL	4.43	6.00	4.58	4.66	4.65	4.81	4.06	5.07	3.66	4.38	4.66	4.50	4.25	4.36	3.77	4.66	5.22	5.44	4.57	3.26	3.96	4.66	3.53	4.03	3.88	5.42	4.47	8.07	0.86

Table 37. Daily evaporation (inches), 1962-1987, Stoneville, November.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.08	0.25	0.15	0.19	0.05	0.08	0.08	0.08	0.08	0.12	0.08	0.08	0.08	0.11	0.08	0.17	0.18	0.10	0.09	0.01	0.12	0.06	0.14	0.02	0.14	0.19	0.11	0.25	0.01
2	0.08	0.14	0.06	0.19	0.07	0.08	0.08	0.08	0.08	0.23	0.08	0.08	0.08	0.16	0.08	0.07	0.14	0.13	0.11	0.07	0.06	0.13	0.12	0.02	0.10	0.14	0.10	0.23	0.02
3	0.08	0.14	0.17	0.15	0.03	0.08	0.08	0.08	0.08	0.20	0.08	0.08	0.08	0.10	0.10	0.10	0.16	0.17	0.04	0.09	0.03	0.16	0.14	0.01	0.17	0.22	0.11	0.22	0.01
4	0.07	0.16	0.15	0.12	0.14	0.07	0.07	0.07	0.07	0.11	0.07	0.07	0.07	0.02	0.09	0.00	0.15	0.07	0.10	0.13	0.09	0.08	0.07	0.10	0.06	0.15	0.09	0.16	0.00
5	0.08	0.11	0.14	0.07	0.10	0.08	0.08	0.08	0.08	0.16	0.08	0.08	0.08	0.05	0.15	0.12	0.15	0.11	0.14	0.16	0.10	0.15	0.08	0.19	0.10	0.20	0.11	0.20	0.05
6	0.07	0.03	0.13	0.04	0.15	0.07	0.07	0.07	0.07	0.22	0.07	0.07	0.07	0.04	0.15	0.02	0.08	0.10	0.12	0.09	0.12	0.12	0.14	0.37	0.06	0.35	0.10	0.35	0.02
7	0.07	0.10	0.16	0.10	0.09	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.16	0.11	0.07	0.14	0.15	0.12	0.10	0.03	0.11	0.11	0.11	0.19	0.10	0.19	0.03
8	0.08	0.12	0.09	0.10	0.20	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.07	0.14	0.18	0.09	0.07	0.20	0.18	0.14	0.02	0.16	0.16	0.00	0.10	0.11	0.20	0.00
9	0.08	0.11	0.13	0.06	0.11	0.08	0.08	0.08	0.08	0.10	0.08	0.08	0.08	0.13	0.12	0.16	0.02	0.26	0.16	0.11	0.11	0.09	0.12	0.18	0.00	0.33	0.11	0.33	0.00
10	0.07	0.05	0.04	0.03	0.13	0.07	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.17	0.13	0.15	0.19	0.00	0.05	0.13	0.10	0.16	0.12	0.13	0.17	0.00	0.09	0.19	0.00
11	0.06	0.21	0.11	0.06	0.01	0.06	0.06	0.06	0.06	0.10	0.06	0.06	0.06	0.06	0.10	0.12	0.05	0.00	0.16	0.09	0.13	0.08	0.19	0.05	0.07	0.00	0.08	0.21	0.00
12	0.08	0.21	0.13	0.08	0.12	0.08	0.08	0.08	0.08	0.14	0.08	0.08	0.08	0.26	0.11	0.13	0.06	0.08	0.16	0.06	0.17	0.00	0.09	0.09	0.05	0.00	0.10	0.26	0.00
13	0.06	0.18	0.04	0.00	0.07	0.06	0.06	0.06	0.06	0.20	0.06	0.06	0.06	0.14	0.07	0.07	0.13	0.09	0.14	0.08	0.00	0.07	0.08	0.12	0.00	0.00	0.08	0.20	0.00
14	0.06	0.10	0.08	0.04	0.11	0.06	0.06	0.06	0.06	0.17	0.06	0.06	0.06	0.07	0.07	0.13	0.06	0.09	0.08	0.09	0.00	0.14	0.08	0.10	0.00	0.39	0.08	0.17	0.00
15	0.06	0.09	0.18	0.04	0.05	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.11	0.06	0.13	0.07	0.06	0.03	0.11	0.00	0.31	0.12	0.03	0.00	0.08	0.08	0.31	0.00
16	0.05	0.11	0.08	0.08	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.01	0.04	0.16	0.13	0.06	0.10	0.08	0.11	0.05	0.07	0.30	0.00	0.07	0.16	0.00
17	0.07	0.13	0.16	0.13	0.12	0.07	0.07	0.07	0.07	0.11	0.07	0.07	0.07	0.10	0.01	0.17	0.03	0.09	0.08	0.09	0.02	0.09	0.16	0.08	0.00	0.00	0.09	0.17	0.00
18	0.07	0.12	0.13	0.08	0.12	0.07	0.07	0.07	0.07	0.09	0.07	0.07	0.07	0.08	0.06	0.13	0.06	0.19	0.02	0.22	0.01	0.17	0.04	0.09	0.05	0.11	0.09	0.22	0.01
19	0.06	0.12	0.08	0.09	0.05	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.16	0.09	0.04	0.09	0.03	0.08	0.06	0.00	0.13	0.13	0.19	0.11	0.14	0.08	0.19	0.00
20	0.06	0.19	0.10	0.08	0.04	0.06	0.06	0.06	0.06	0.13	0.06	0.06	0.06	0.15	0.10	0.12	0.08	0.07	0.00	0.06	0.11	0.22	0.03	0.05	0.06	0.09	0.08	0.22	0.00
21	0.06	0.02	0.07	0.00	0.10	0.06	0.06	0.06	0.06	0.14	0.06	0.06	0.06	0.10	0.03	0.05	0.06	0.33	0.00	0.06	0.12	0.12	0.13	0.11	0.13	0.12	0.08	0.23	0.00
22	0.05	0.14	0.10	0.14	0.23	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.04	0.01	0.05	0.00	0.06	0.07	0.03	0.13	0.00	0.06	0.38	0.09	0.07	0.23	0.00
23	0.05	0.11	0.00	0.14	0.03	0.05	0.05	0.05	0.05	0.15	0.05	0.05	0.05	0.04	0.07	0.01	0.03	0.00	0.04	0.14	0.02	0.24	0.00	0.06	0.11	0.15	0.07	0.24	0.00
24	0.04	0.05	0.00	0.08	0.09	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.07	0.08	0.03	0.14	0.03	0.00	0.13	0.10	0.10	0.04	0.04	0.10	0.12	0.06	0.14	0.00
25	0.06	0.12	0.14	0.12	0.10	0.06	0.06	0.06	0.06	0.03	0.06	0.06	0.06	0.05	0.08	0.00	0.16	0.17	0.06	0.17	0.10	0.07	0.08	0.00	0.05	0.11	0.08	0.17	0.00
26	0.03	0.04	0.00	0.05	0.04	0.03	0.03	0.03	0.03	0.07	0.03	0.03	0.03	0.01	0.09	0.00	0.05	0.22	0.04	0.07	0.04	0.15	0.03	0.02	0.00	0.06	0.04	0.15	0.00
27	0.05	0.01	0.09	0.21	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.12	0.01	0.11	0.08	0.05	0.08	0.02	0.04	0.12	0.09	0.04	0.01	0.07	0.21	0.01
28	0.05	0.04	0.12	0.13	0.17	0.05	0.05	0.05	0.05	0.03	0.05	0.05	0.05	0.06	0.04	0.00	0.02	0.12	0.03	0.02	0.00	0.09	0.02	0.24	0.03	0.11	0.07	0.24	0.00
29	0.04	0.07	0.00	0.10	0.10	0.04	0.04	0.04	0.04	0.11	0.04	0.04	0.04	0.12	0.07	0.00	0.05	0.00	0.07	0.07	0.05	0.09	0.09	0.03	0.04	0.08	0.06	0.12	0.00
30	0.03	0.08	0.13	0.12	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.00	0.02	0.03	0.00	0.09	0.09	0.10	0.03	0.11	0.00	0.00	0.03	0.05	0.13	0.00
TOTAL	1.85	3.35	2.96	2.82	2.90	1.85	1.85	1.85	1.85	3.20	1.85	1.85	1.85	2.75	2.50	2.29	2.81	2.63	2.41	2.95	2.13	3.38	2.84	2.51	1.82	3.32	2.51	6.29	0.16

Table 38. Daily evaporation (inches), 1962-1987, Stoneville, December.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVG	MAX	MIN
1	0.04	0.14	0.14	0.00	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.00	0.04	0.05	0.00	0.14	0.04	0.20	0.03	0.07	0.12	0.00	0.05	0.05	0.20	0.00
2	0.05	0.11	0.00	0.13	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.00	0.10	0.11	0.00	0.07	0.13	0.21	0.06	0.11	0.10	0.04	0.00	0.07	0.21	0.00
3	0.02	0.00	0.14	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.08	0.00	0.01	0.02	0.00	0.00	0.09	0.10	0.00	0.04	0.00	0.06	0.00	0.03	0.14	0.00
4	0.03	0.11	0.06	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.00	0.14	0.03	0.00	0.00	0.14	0.00	0.00	0.10	0.00	0.05	0.09	0.04	0.14	0.00
5	0.04	0.09	0.30	0.13	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.05	0.00	0.06	0.00	0.09	0.04	0.06	0.06	0.05	0.00	0.07	0.13	0.06	0.30	0.00
6	0.04	0.08	0.00	0.17	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.10	0.06	0.00	0.09	0.13	0.06	0.04	0.08	0.13	0.00	0.00	0.00	0.11	0.06	0.17	0.00
7	0.03	0.07	0.00	0.11	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.03	0.00	0.11	0.09	0.02	0.03	0.07	0.00	0.00	0.00	0.08	0.07	0.04	0.11	0.00
8	0.03	0.16	0.00	0.11	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.00	0.11	0.03	0.10	0.00	0.05	0.08	0.09	0.00	0.00	0.10	0.08	0.05	0.16	0.00
9	0.03	0.00	0.00	0.12	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.00	0.00	0.03	0.00	0.11	0.14	0.09	0.06	0.07	0.00	0.10	0.14	0.05	0.14	0.00
10	0.03	0.00	0.19	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.07	0.00	0.00	0.03	0.00	0.04	0.09	0.01	0.02	0.04	0.09	0.07	0.10	0.04	0.19	0.00
11	0.04	0.00	0.12	0.11	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.08	0.00	0.00	0.04	0.13	0.03	0.11	0.00	0.09	0.08	0.14	0.11	0.05	0.06	0.14	0.00
12	0.03	0.00	0.11	0.06	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.10	0.02	0.00	0.03	0.06	0.06	0.01	0.00	0.14	0.06	0.00	0.02	0.00	0.04	0.14	0.00
13	0.03	0.01	0.07	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.07	0.02	0.15	0.03	0.06	0.09	0.04	0.00	0.03	0.06	0.00	0.00	0.00	0.04	0.15	0.00
14	0.02	0.04	0.03	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.11	0.00	0.07	0.02	0.03	0.10	0.03	0.00	0.01	0.12	0.00	0.00	0.00	0.03	0.12	0.00
15	0.02	0.04	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.10	0.00	0.02	0.04	0.07	0.05	0.03	0.00	0.08	0.09	0.00	0.01	0.00	0.03	0.10	0.00
16	0.03	0.03	0.14	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.11	0.03	0.03	0.05	0.04	0.07	0.08	0.14	0.00	0.00	0.00	0.04	0.14	0.00
17	0.03	0.03	0.13	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.10	0.19	0.03	0.00	0.08	0.13	0.00	0.00	0.06	0.00	0.00	0.00	0.04	0.19	0.00
18	0.02	0.03	0.12	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.11	0.03	0.03	0.00	0.06	0.04	0.00	0.00	0.05	0.00	0.01	0.00	0.03	0.12	0.00
19	0.03	0.03	0.00	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.08	0.13	0.09	0.00	0.11	0.04	0.06	0.00	0.06	0.00	0.05	0.00	0.04	0.13	0.00
20	0.02	0.03	0.00	0.09	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.00	0.13	0.00	0.00	0.04	0.08	0.00	0.02	0.00	0.06	0.00	0.03	0.13	0.00
21	0.01	0.03	0.00	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.07	0.02	0.00	0.03	0.07	0.00	0.02	0.00	0.04	0.00	0.02	0.08	0.00
22	0.03	0.03	0.11	0.09	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.09	0.00	0.00	0.07	0.07	0.00	0.03	0.08	0.00	0.10	0.00	0.09	0.00	0.04	0.11	0.00
23	0.02	0.03	0.00	0.12	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.00	0.02	0.07	0.07	0.00	0.03	0.06	0.00	0.12	0.00	0.00	0.00	0.03	0.12	0.00
24	0.02	0.03	0.00	0.11	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.00	0.07	0.02	0.07	0.00	0.05	0.08	0.00	0.05	0.09	0.00	0.00	0.03	0.11	0.00
25	0.02	0.03	0.13	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.00	0.00	0.02	0.10	0.00	0.02	0.11	0.00	0.11	0.00	0.02	0.00	0.03	0.13	0.00
26	0.02	0.03	0.15	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.02	0.08	0.00	0.02	0.00	0.00	0.10	0.00	0.00	0.00	0.03	0.15	0.00
27	0.02	0.03	0.06	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.00	0.00	0.02	0.05	0.00	0.03	0.05	0.00	0.04	0.00	0.03	0.00	0.02	0.07	0.00
28	0.03	0.05	0.05	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.07	0.11	0.00	0.03	0.05	0.00	0.09	0.24	0.00	0.00	0.00	0.03	0.00	0.04	0.24	0.00
29	0.03	0.08	0.07	0.06	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.11	0.00	0.01	0.04	0.00	0.12	0.04	0.00	0.08	0.00	0.01	0.00	0.04	0.12	0.00
30	0.02	0.07	0.12	0.08	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.10	0.01	0.02	0.01	0.00	0.02	0.00	0.00	0.03	0.00	0.06	0.00	0.03	0.12	0.00
31	0.02	0.04	0.10	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.00	0.00	0.02	0.03	0.08	0.02	0.00	0.00	0.06	0.00	0.00	0.00	0.02	0.10	0.00
TOTAL	0.85	1.45	2.34	2.24	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	1.56	0.84	1.20	1.40	1.29	1.24	1.76	1.84	0.88	1.33	0.54	1.11	0.82	1.21	4.47	0.00

Table 39. Weekly DD60 accumulation and probabilities, Canton.

Growing Season Weekly Accumulation of DD60s,
Canton, MS 1951-1980

Probability That Weekly Accumulation of DD60s
Will Be Equal To Or Less Than The Indicated Amounts

Week Of	Mean	Max	Min	STDev	99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	60	110	2	27.7	110	94	85	78	69	54	49	39	34	27
May 10	76	122	11	29.4	122	110	106	95	85	76	66	60	51	31
May 17	94	127	38	23.0	127	119	110	105	103	100	95	85	67	56
May 24	103	147	45	23.1	147	123	119	116	111	107	101	97	86	54
May 31	108	154	72	21.9	154	132	126	121	114	109	106	91	83	75
Jun 7	129	175	69	20.6	175	151	143	138	134	128	123	119	114	106
Jun 14	131	184	78	23.1	184	160	151	143	137	132	119	116	114	99
Jun 21	139	177	82	22.4	177	166	158	152	148	140	136	126	120	112
Jun 28	148	179	112	17.6	179	170	165	156	148	146	142	138	134	119
Jul 5	146	181	97	18.9	181	168	159	155	151	147	145	141	128	118
Jul 12	143	187	94	19.2	187	174	162	156	155	151	145	140	133	124
Jul 19	150	179	119	13.7	179	165	161	157	152	147	146	145	143	126
Jul 26	152	172	112	11.8	172	164	158	155	155	153	151	149	143	137
Aug 2	148	178	113	17.2	178	166	165	159	155	147	146	142	129	120
Aug 9	145	173	107	15.1	173	165	158	155	149	142	141	138	131	126
Aug 16	145	181	114	16.2	181	164	158	155	148	145	138	136	134	117
Aug 23	135	182	95	19.9	182	156	151	149	138	129	127	120	117	108
Aug 30	133	187	69	22.6	187	151	146	144	138	137	133	128	116	97
Sep 6	120	150	78	22.1	150	145	140	132	131	127	117	106	91	82
Sep 13	106	149	38	28.0	149	144	137	119	113	106	96	88	81	71
Sep 20	100	147	29	26.8	147	136	124	115	111	95	92	86	83	61
Sep 27	76	150	5	37.5	150	126	119	91	77	68	65	53	47	22

1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s
Will Be Equal To Or Greater Than The Indicated Amounts

Table 40. Weekly DD60 accumulation and probabilities, Clarksdale.

Growing Season Weekly Accumulation of DD60s, Clarksdale, MS 1951-1980

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Less Than The Indicated Amounts

Week Of	Mean	Max	Min	STDev	99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	67	145.5	18.5	31.7	146	115	91	80	67	59	51	43	41	26
May 10	78	147.0	30.5	30.1	147	116	102	90	75	71	68	57	52	38
May 17	102	157.5	40.5	25.6	158	133	121	114	107	100	96	92	83	59
May 24	110	170.5	42.5	29.3	171	134	131	127	122	114	109	93	90	54
May 31	117	165.0	68.0	26.5	165	153	142	128	123	115	108	105	85	79
Jun 7	139	207.5	72.0	26.9	208	174	155	147	139	138	132	129	118	105
Jun 14	140	221.0	76.5	30.6	221	179	157	153	144	138	131	126	107	101
Jun 21	147	202.5	98.0	26.5	203	183	167	156	154	148	145	137	123	102
Jun 28	159	198.5	122.0	19.9	199	191	177	163	156	155	149	147	143	137
Jul 5	158	201.5	93.0	24.7	202	184	179	174	169	156	153	149	135	123
Jul 12	160	208.0	112.5	24.4	208	193	179	173	169	159	145	144	141	126
Jul 19	159	192.0	100.0	18.5	192	178	176	166	161	160	155	152	142	138
Jul 26	157	197.5	102.0	19.2	198	179	171	167	162	157	155	145	139	135
Aug 2	155	192.5	118.0	23.1	193	182	180	172	164	153	141	138	128	120
Aug 9	149	192.5	99.0	21.6	193	186	165	153	151	147	142	139	131	121
Aug 16	148	198.0	109.0	20.3	198	167	165	159	155	149	140	136	129	119
Aug 23	141	193.5	97.5	20.6	194	160	154	153	145	142	135	128	122	113
Aug 30	135	199.5	68.0	27.1	200	156	155	152	143	139	129	124	116	95
Sep 6	121	154.0	71.0	23.2	154	146	142	137	133	126	119	104	92	84
Sep 13	106	150.0	49.5	29	150	144	130	125	114	105	98	89	77	66
Sep 20	94	139.5	25.5	29.4	140	128	116	114	98	93	87	80	66	54
Sep 27	74	155.0	23.5	36.2	155	124	103	91	70	67	60	49	36	30

1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Greater Than The Indicated Amounts

Table 41. Weekly DD60 accumulation and probabilities, Corinth.

Growing Season weekly Accumulation of DD60s.
Corinth, MS 1951-1980

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Less Than The Indicated Amounts

Week Of	Mean	Max	Min	STDev	99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	53	122.0	12.0	28.1	122	88	80	68	52	45	39	34	32	16
May 10	65	135.5	16.5	28.0	136	93	84	78	67	64	55	45	38	31
May 17	83	140.5	33.5	24.6	141	110	102	96	94	81	79	74	65	57
May 24	91	149.5	36.5	26.8	150	118	111	101	98	94	88	82	64	50
May 31	99	133.5	48.5	23.0	139	127	116	114	111	105	94	79	76	63
Jun 7	120	183.5	37.5	25.5	184	148	129	123	120	119	115	108	106	95
Jun 14	120	185.5	71.5	26.1	186	153	136	129	124	119	117	110	96	82
Jun 21	129	190.0	91.0	26.0	190	163	151	139	136	132	120	116	104	97
Jun 28	141	185.0	103.5	20.7	185	173	166	143	140	136	134	129	122	116
Jul 5	138	198.5	82.0	24.7	199	167	154	150	144	139	135	124	110	103
Jul 12	143	211.0	100.5	25.3	211	169	165	149	142	135	130	129	123	104
Jul 19	145	191.5	105.5	17.7	192	164	156	151	149	145	145	140	133	123
Jul 26	146	193.0	90.5	19.0	193	164	157	154	153	151	146	139	129	125
Aug 2	141	175.5	99.5	22.3	176	170	163	156	152	144	132	125	115	107
Aug 9	135	175.5	81.0	19.3	176	162	151	142	136	135	129	127	123	111
Aug 16	137	193.5	102.0	20.2	184	161	150	148	144	136	128	121	116	109
Aug 23	128	188.0	67.5	23.9	189	155	145	139	134	126	122	116	103	96
Aug 30	124	184.0	39.0	28.8	184	148	147	140	135	130	114	110	99	88
Sep 6	103	147.0	66.0	22.4	147	134	129	121	120	113	109	99	91	75
Sep 13	92	145.5	28.5	28.3	146	132	123	103	99	91	93	90	70	53
Sep 20	81	131.0	16.0	28.5	131	115	110	105	94	72	68	62	56	46
Sep 27	61	145.0	9.5	33.5	145	112	78	71	64	56	50	34	30	24

1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Greater Than The Indicated Amounts

Table 42. Weekly DD60 accumulation and probabilities, Holly Springs.

Growing Season Weekly Accumulation of DD60s,
Holly Springs, MS 1951-1980

Probability That Weekly Accumulation of DD60s
Will Be Equal To Or Less Than The Indicated Amounts

Week Of	Mean	Max	Min	STDev	99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	45	117.0	4.5	27.7	117	85	66	58	39	33	31	27	23	11
May 10	54	117.0	13.0	28.7	117	89	83	63	52	47	41	30	26	23
May 17	72	121.0	18.0	26.6	121	101	97	92	81	67	64	60	47	29
May 24	80	139.0	19.5	27.5	139	104	97	93	90	86	73	68	59	37
May 31	86	123.0	35.5	24.1	128	118	109	102	88	84	80	74	60	55
Jun 7	109	173.0	45.0	26.5	173	143	126	116	114	108	102	94	83	79
Jun 14	111	181.0	54.5	28.9	181	144	127	123	115	108	103	97	83	77
Jun 21	119	180.0	66.0	26.9	180	153	137	130	125	117	113	108	95	77
Jun 28	131	177.0	99.0	22.5	177	165	155	135	128	126	124	117	108	104
Jul 5	130	188.5	63.5	27.0	189	159	151	142	137	133	129	122	107	89
Jul 12	136	205.5	78.0	28.6	206	170	156	148	135	130	124	121	115	94
Jul 19	137	179.5	88.5	18.3	180	152	147	144	139	136	135	133	125	111
Jul 26	138	179.0	84.5	19.1	179	155	153	150	146	145	136	127	121	114
Aug 2	133	175.5	81.5	27.7	176	166	159	151	146	138	120	115	101	87
Aug 9	127	169.5	73.0	23.2	170	160	150	139	125	123	121	113	108	101
Aug 16	127	182.0	92.5	22.7	182	150	144	139	135	128	118	111	104	94
Aug 23	119	173.0	64.5	23.0	173	143	136	131	127	122	113	110	97	85
Aug 30	114	171.5	35.0	29.1	172	141	135	134	125	118	109	101	86	74
Sep 6	98	132.5	42.5	22.2	133	122	118	110	108	104	95	79	76	64
Sep 13	85	151.0	27.0	31.5	151	119	115	103	95	92	79	66	50	35
Sep 20	73	134.5	16.5	29.7	135	111	98	96	76	71	60	53	46	34
Sep 27	55	138.5	6.5	35.3	139	108	80	71	53	46	33	31	22	14

1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s
Will Be Equal To Or Greater Than The Indicated Amounts

Table 43. Weekly DD60 accumulation and probabilities, Meridian.

Growing Season Weekly Accumulation of DD60s.
Meridian, MS 1951-1980

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Less Than The Indicated Amounts

Week Of	Mean	Max	Min	STDev	99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	61	110.5	9.5	25.8	111	94	86	72	64	58	52	47	39	25
May 10	76	130.0	15.0	30.2	130	115	107	96	88	69	56	55	46	43
May 17	93	127.5	26.0	22.9	128	118	113	105	101	97	90	86	81	58
May 24	104	152.0	43.5	23.9	152	124	119	117	107	106	102	101	96	55
May 31	107	144.0	65.0	21.2	144	132	121	118	115	112	107	95	82	75
Jun 7	128	176.0	66.5	22.3	176	152	145	137	135	130	125	119	110	102
Jun 14	132	177.0	75.0	23.1	177	157	151	145	142	135	126	116	112	103
Jun 21	139	178.0	91.0	22.5	178	166	160	148	146	142	140	131	115	103
Jun 28	147	180.5	109.5	18.9	181	171	167	153	149	145	142	137	134	116
Jul 5	146	183.5	100.0	19.2	184	167	157	153	152	149	144	137	132	120
Jul 12	150	191.5	103.5	16.9	192	166	163	159	154	150	144	139	136	129
Jul 19	150	178.5	121.5	13.7	179	168	163	154	151	146	145	143	136	130
Jul 26	150	170.5	122.0	10.3	171	162	158	157	154	150	148	145	142	136
Aug 2	150	177.0	114.5	16.0	177	169	162	159	156	155	146	140	135	125
Aug 9	145	180.5	103.0	17.3	181	170	159	153	148	141	136	135	130	129
Aug 16	145	184.5	116.5	16.3	185	170	156	152	148	145	143	134	131	121
Aug 23	136	177.5	90.0	19.2	178	157	153	147	146	134	128	126	118	108
Aug 30	135	187.0	63.5	22.6	187	154	149	143	141	140	138	132	119	102
Sep 6	123	167.0	74.0	23.9	167	149	144	136	134	124	123	115	92	84
Sep 13	108	155.0	45.0	26.1	155	142	134	122	119	102	93	91	85	77
Sep 20	100	154.0	46.5	26.7	154	134	121	118	109	91	89	80	77	68
Sep 27	77	139.5	12.5	33.5	140	124	110	90	78	77	69	56	51	26

1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Greater Than The Indicated Amounts

Table 44. Weekly DD60 accumulation and probabilities, Mississippi State.

Growing Season Weekly Accumulation of DD60s,
Mississippi State, MS 1951-1980

Probability That Weekly Accumulation of DD60s
Will Be Equal To Or Less Than The Indicated Amounts

Week Of	Mean	Max	Min	STDev	99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	57	113	4	28.5	118	95	83	70	61	58	45	36	28	19
May 10	72	129	13	29.6	129	105	97	89	81	69	64	50	47	29
May 17	91	140	29	24.7	140	118	111	107	95	92	86	82	76	49
May 24	97	148	42	25.5	148	116	115	114	110	104	93	84	74	49
May 31	106	147	62	21.3	147	134	120	119	112	107	99	96	86	73
Jun 7	127	180	64	22.2	180	150	143	135	131	123	120	112	108	104
Jun 14	129	185	70	24.8	185	154	150	146	139	125	119	118	108	96
Jun 21	136	181	79	24.6	181	160	157	154	142	139	132	119	115	99
Jun 28	146	181	109	20.4	181	176	171	157	146	143	138	132	131	115
Jul 5	144	197	94	22.9	197	171	150	148	146	144	143	134	125	108
Jul 12	147	221	94	24.8	221	171	164	157	153	145	141	139	122	117
Jul 19	149	183	118	14.1	183	167	156	155	152	149	148	143	138	124
Jul 26	149	187	106	14.6	187	164	161	156	155	150	143	141	138	133
Aug 2	149	187	112	18.9	187	172	168	157	154	150	145	139	126	123
Aug 9	143	184	94	19.0	184	168	164	148	144	140	137	133	128	123
Aug 16	144	190	107	18.7	190	166	158	152	147	142	138	136	132	117
Aug 23	134	186	89	19.8	186	156	150	143	137	133	130	125	115	107
Aug 30	131	186	57	26.4	186	155	151	147	139	134	128	123	111	96
Sep 6	119	166	82	20.8	166	146	132	129	127	119	111	107	102	83
Sep 13	105	155	47	27.7	156	139	131	122	110	105	92	91	81	62
Sep 20	95	158	20	29.5	158	130	113	110	102	94	84	82	68	61
Sep 27	72	155	8	36.4	155	123	103	88	78	72	55	47	38	20
					1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s
Will Be Equal To Or Greater Than The Indicated Amounts

Table 45. Weekly DD60 accumulation and probabilities, Onward.

Growing Season Weekly Accumulation of DD60s.
Onward, MS 1955-1980

Week Of	Mean	Max	Min	STDev	Probability That Weekly Accumulation of DD60s Will Be Equal To Or Less Than The Indicated Amounts									
					99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	64	106.5	30.5	21.4	107	87	82	76	75	68	54	51	46	39
May 10	79	121.5	24.0	24.2	122	104	103	100	84	79	76	63	57	47
May 17	93	123.5	41.0	20.2	124	109	107	105	101	99	96	89	77	56
May 24	103	135.0	51.0	21.2	135	124	120	117	114	107	104	90	86	65
May 31	101	152.0	57.5	23.3	152	129	117	112	109	101	93	90	85	65
Jun 7	123	160.5	68.5	17.5	161	140	136	131	130	121	120	115	115	109
Jun 14	125	157.5	77.0	22.0	158	155	146	136	134	121	115	110	104	100
Jun 21	131	173.0	83.5	21.6	173	156	149	141	138	129	126	123	112	104
Jun 28	142	181.0	101.0	19.2	181	166	157	147	145	144	137	134	130	117
Jul 5	143	186.0	99.5	21.6	186	162	159	152	151	140	138	135	123	117
Jul 12	144	196.0	93.0	20.1	196	168	155	153	148	146	141	135	131	119
Jul 19	144	168.5	103.0	13.5	169	159	154	151	150	145	142	141	135	129
Jul 26	146	168.0	109.5	12.4	168	159	157	152	150	146	145	142	136	133
Aug 2	143	168.5	115.5	15.7	169	159	157	154	153	145	140	130	124	123
Aug 9	137	165.5	98.5	15.7	166	155	151	146	144	139	134	129	126	116
Aug 16	138	167.0	105.0	15.9	167	156	153	149	144	137	136	130	128	110
Aug 23	128	158.5	94.5	17.9	159	147	146	141	137	129	127	116	110	106
Aug 30	126	147.5	58.5	20.7	148	142	142	139	137	134	126	122	119	92
Sep 6	115	143.5	74.0	21.1	144	134	133	132	127	121	117	101	94	79
Sep 13	99	143.5	36.5	27.5	144	140	130	104	101	99	96	88	75	66
Sep 20	93	139.5	32.0	25.9	140	126	119	103	100	83	84	81	79	56
Sep 27	67	126.0	21.5	31.3	126	122	81	78	72	60	53	45	40	30
					1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s
Will Be Equal To Or Greater Than The Indicated Amounts

Table 46. Weekly DD60 accumulation and probabilities, Stoneville.

Growing Season Weekly Accumulation of DD60s, Stoneville, MS 1951-1980

Week Of	Mean	Max	Min	STDev
May 3	64	129	1	30.7
May 10	77	134	20	28.9
May 17	98	139	45	22.9
May 24	107	147	40	25.9
May 31	113	158	66	22.5
Jun 7	137	182	74	22.3
Jun 14	136	189	80	25.5
Jun 21	144	179	93	22.9
Jun 28	154	183	121	17.6
Jul 5	152	196	100	21.5
Jul 12	153	204	104	22.2
Jul 19	154	179	110	15.1
Jul 26	153	175	102	15.0
Aug 2	151	178	115	18.5
Aug 9	145	179	106	15.9
Aug 16	145	181	109	17.7
Aug 23	135	177	93	19.1
Aug 30	130	184	65	25.0
Sep 6	118	148	70	20.9
Sep 13	103	155	43	29.4
Sep 20	93	149	29	23.0
Sep 27	71	139	15	34.7

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Less Than The Indicated Amounts

Week Of	99%	90%	80%	70%	60%	50%	40%	30%	20%	10%
May 3	129	108	93	79	70	57	51	48	38	27
May 10	134	113	103	101	78	75	67	60	53	32
May 17	139	125	114	109	107	103	96	89	80	56
May 24	147	135	129	125	118	109	102	95	89	62
May 31	158	145	130	125	121	108	105	99	93	81
Jun 7	182	164	155	146	141	135	130	123	119	114
Jun 14	189	175	156	154	136	134	127	119	113	102
Jun 21	179	168	165	162	154	142	137	135	120	102
Jun 28	183	180	166	165	160	149	146	144	139	127
Jul 5	196	175	170	163	162	152	145	142	134	123
Jul 12	204	180	170	160	156	150	144	142	133	126
Jul 19	179	173	167	164	158	152	149	146	145	134
Jul 26	175	168	165	161	158	157	149	145	140	135
Aug 2	178	173	170	164	160	151	144	138	129	124
Aug 9	179	163	158	153	149	145	140	135	129	127
Aug 16	181	166	157	156	152	147	140	137	129	117
Aug 23	177	155	150	145	142	137	130	124	116	110
Aug 30	184	154	146	143	139	136	131	129	106	98
Sep 6	148	142	134	131	124	123	118	108	100	85
Sep 13	155	146	130	119	111	105	89	83	74	64
Sep 20	149	129	117	107	100	96	86	80	68	52
Sep 27	139	124	114	81	70	65	62	47	38	27

Week Of	1%	10%	20%	30%	40%	50%	60%	70%	80%	90%

Probability That Weekly Accumulation of DD60s Will Be Equal To Or Greater Than The Indicated Amounts

Table 47. Weekly crop water demands (inches) based on emergence dates.

Week begins	10 May Sorghum	10 May Cotton	10 May Corn	17 May Soybeans	18 June Soybeans
May 10	0.24	0.11	0.25	-	-
May 17	0.30	0.07	0.36	0.26	-
May 24	0.37	0.10	0.51	0.36	-
May 31	0.56	0.18	0.68	0.43	-
June 7	0.88	0.37	0.88	0.57	-
June 14	1.16	0.50	1.07	0.74	-
June 21	1.40	0.66	1.20	0.91	-
June 28	1.58	0.89	1.39	1.11	0.35
July 5	1.35	1.02	1.39	1.18	0.36
July 12	1.29	1.34	1.53	1.35	0.45
July 19	1.04	1.23	1.40	1.28	0.51
July 26	0.90	1.41	1.38	1.29	0.63
Aug. 2	0.80	1.40	1.37	1.27	0.79
Aug. 9	0.68	1.37	1.24	1.16	0.90
Aug. 16	0.56	1.30	1.07	0.97	1.02
Aug. 23	0.46	1.19	0.88	0.71	1.11
Aug. 30	0.32	0.87	0.56	0.32	1.02
Sep. 6	0.27	0.68	0.68	0.03	1.12
Sep. 13	-	0.32	0.02	-	1.01
Sep. 20	-	0.03	-	-	0.87
Sep. 27	-	-	-	-	0.68
Oct. 4	-	-	-	-	0.51
Oct. 11	-	-	-	-	0.23
Oct. 18	-	-	-	-	0.02
TOTAL	14.16	15.04	17.47	13.94	11.58

Appendix B

Figures

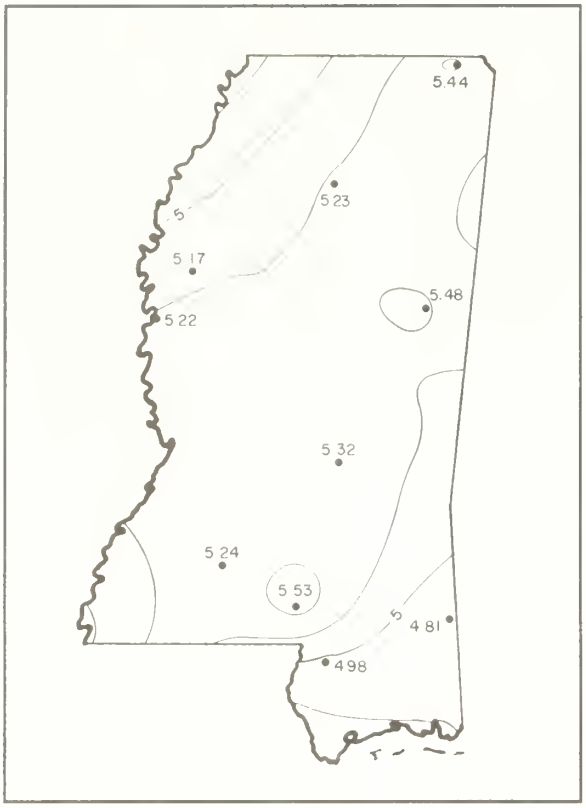

Figure 1. Average monthly precipitation pattern in Mississippi, January.

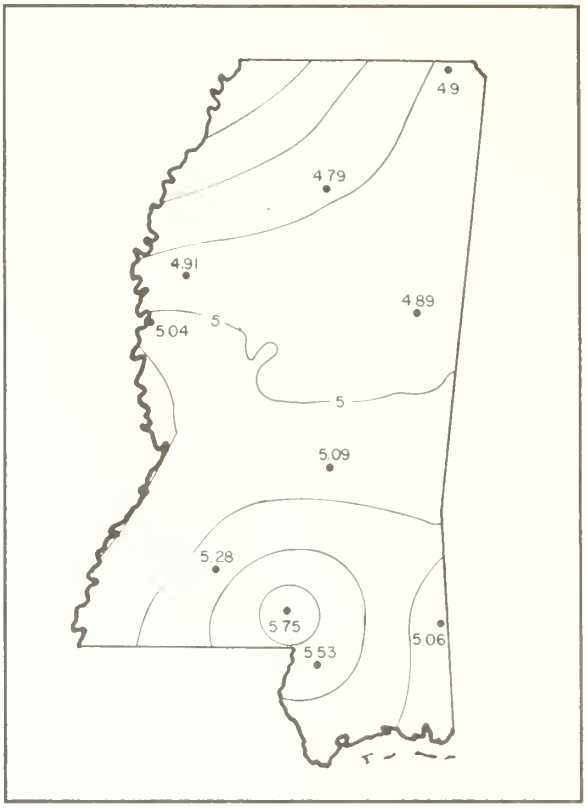

Figure 2. Average monthly precipitation pattern in Mississippi, February.

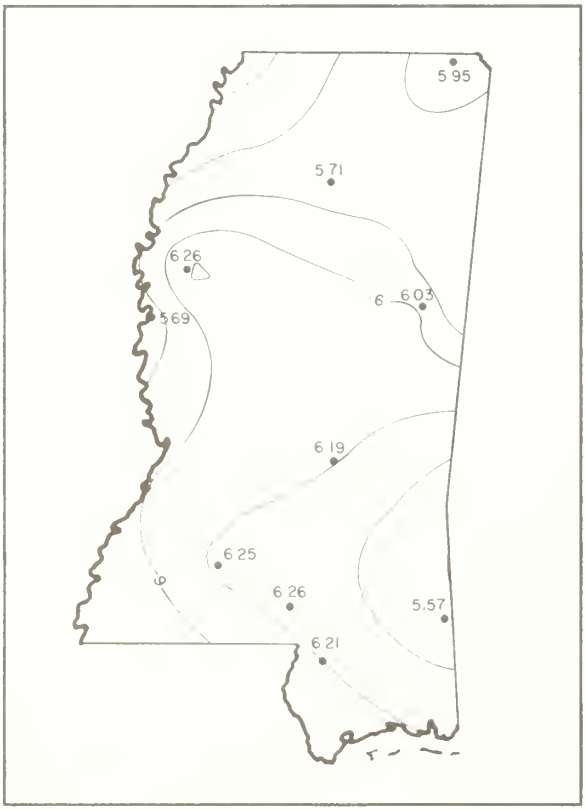

Figure 3. Average monthly precipitation pattern in Mississippi, March.

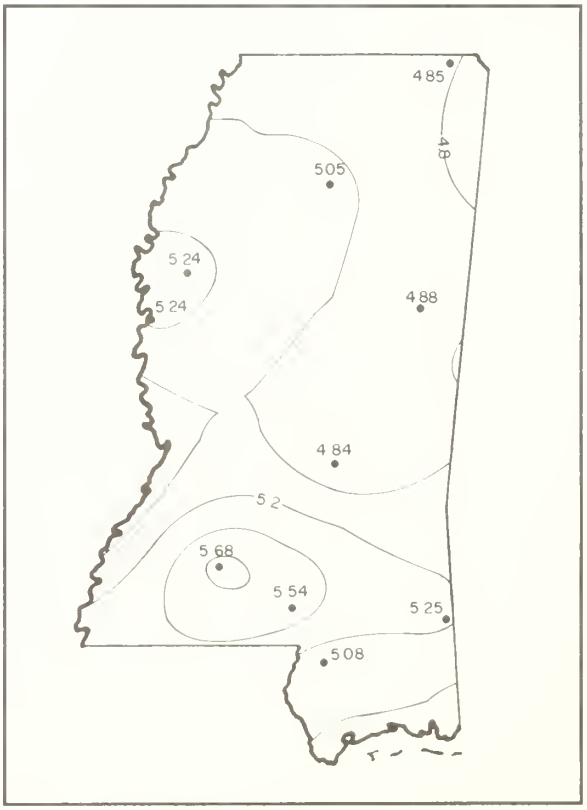

Figure 4. Average monthly precipitation pattern in Mississippi, April.

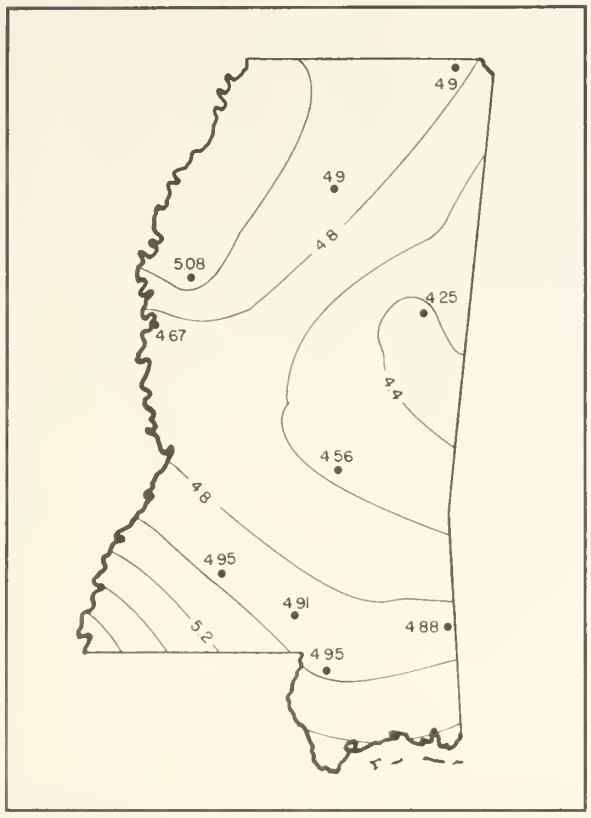

Figure 5. Average monthly precipitation pattern in Mississippi, May.

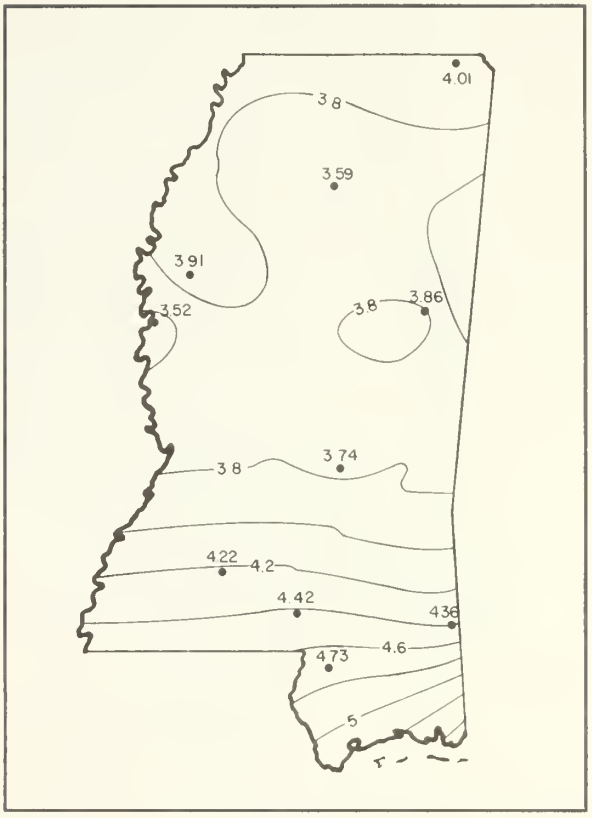

Figure 6. Average monthly precipitation pattern in Mississippi, June.

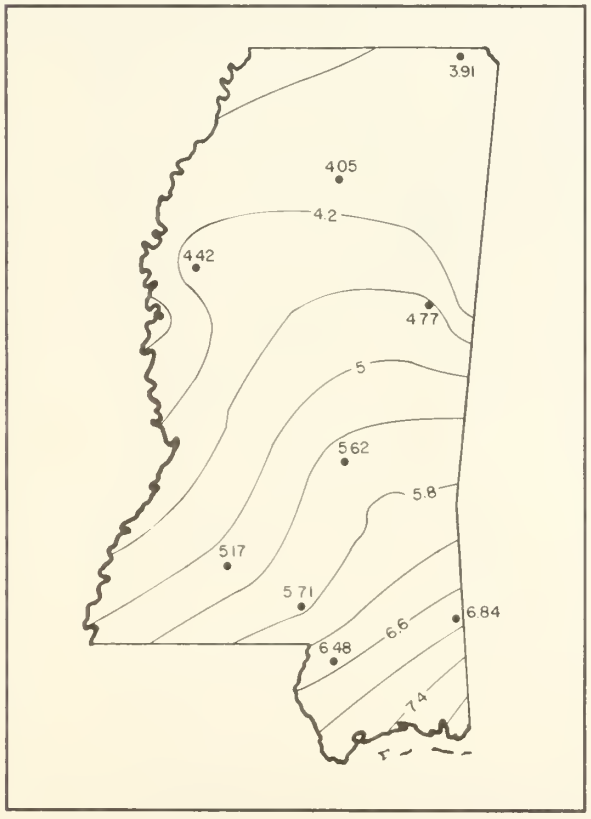

Figure 7. Average monthly precipitation pattern in Mississippi, July.

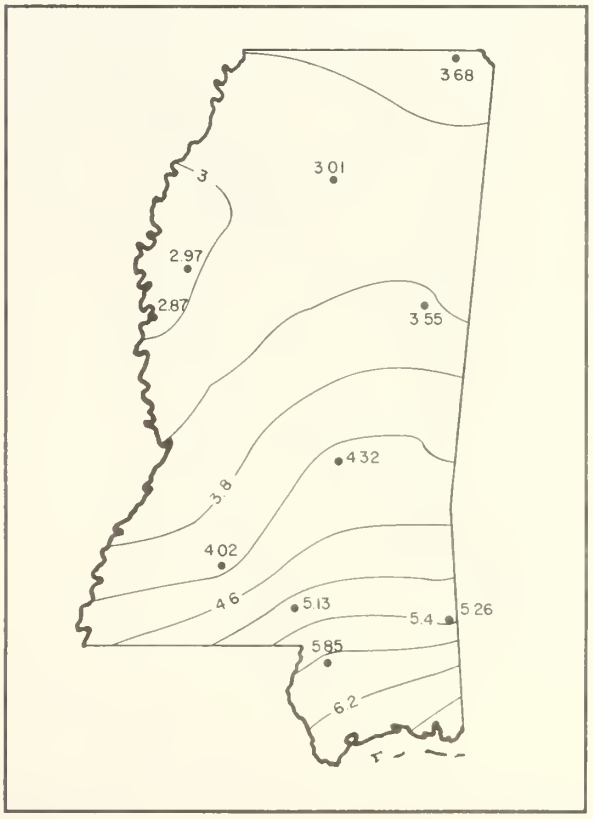

Figure 8. Average monthly precipitation pattern in Mississippi, August.

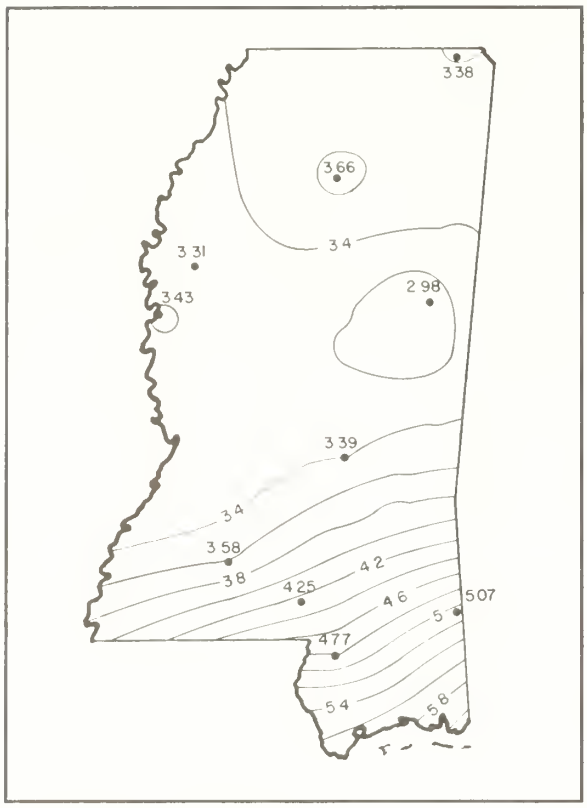

Figure 9. Average monthly precipitation pattern in Mississippi, September.

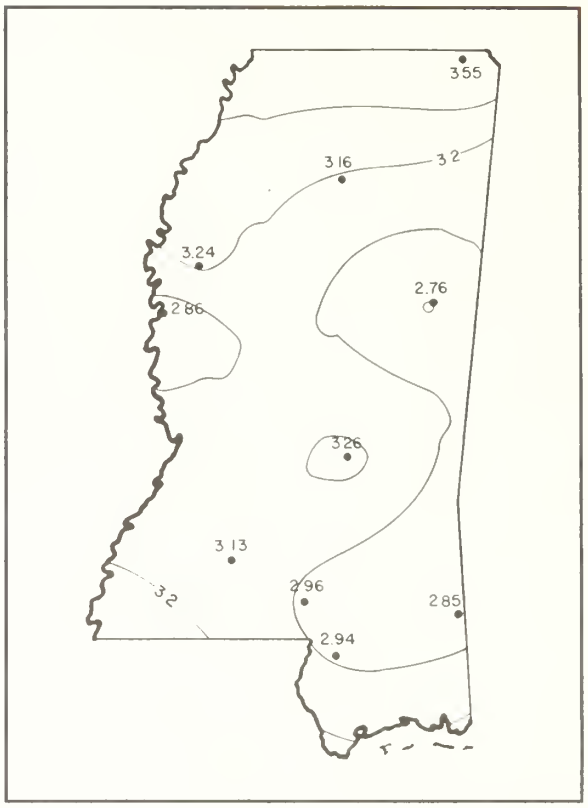

Figure 10. Average monthly precipitation pattern in Mississippi, October.

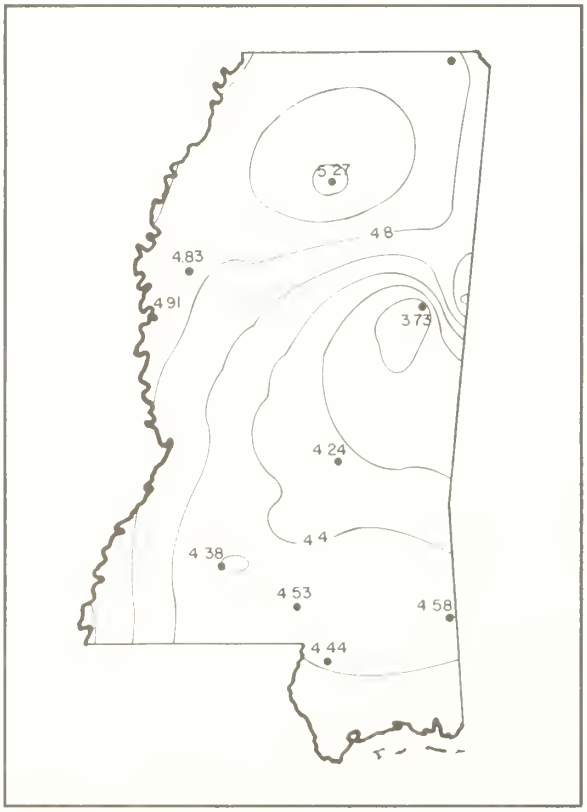

Figure 11. Average monthly precipitation pattern in Mississippi, November.

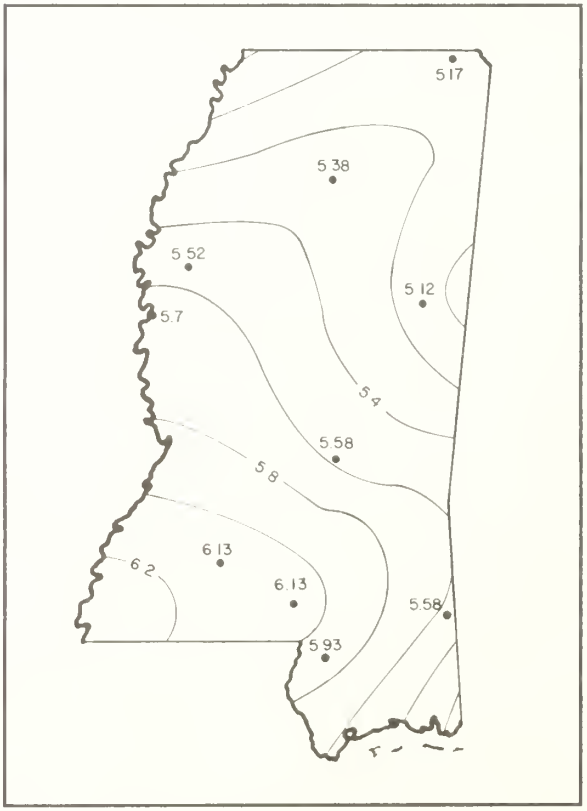

Figure 12. Average monthly precipitation pattern in Mississippi, December.

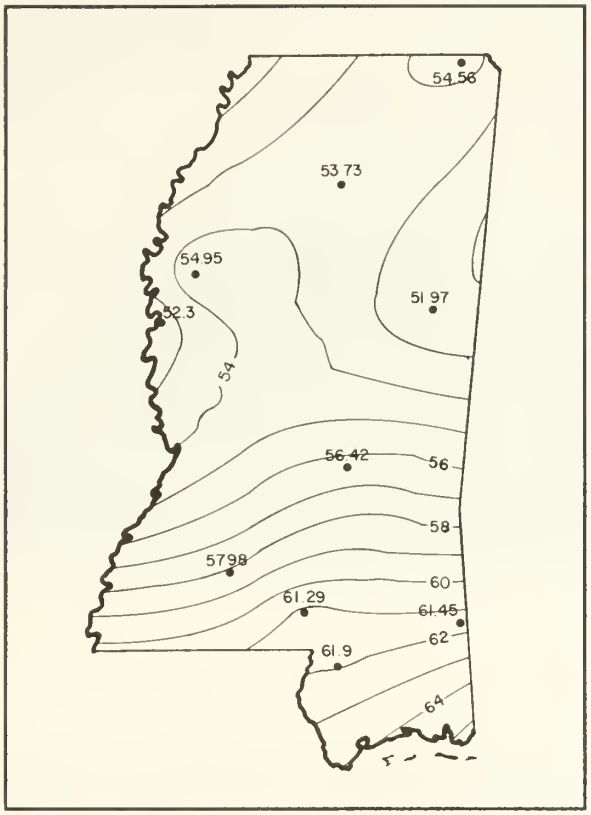

Figure 13. Average annual precipitation pattern in Mississippi.

Figure 14. Average daily high and low temperatures, North Mississippi (Water Valley).

Figure 15. Average daily high and low temperatures, Central Misissippi (Canton).

Figure 16. Average daily high and low temperatures, South Mississippi (Hattiesburg).

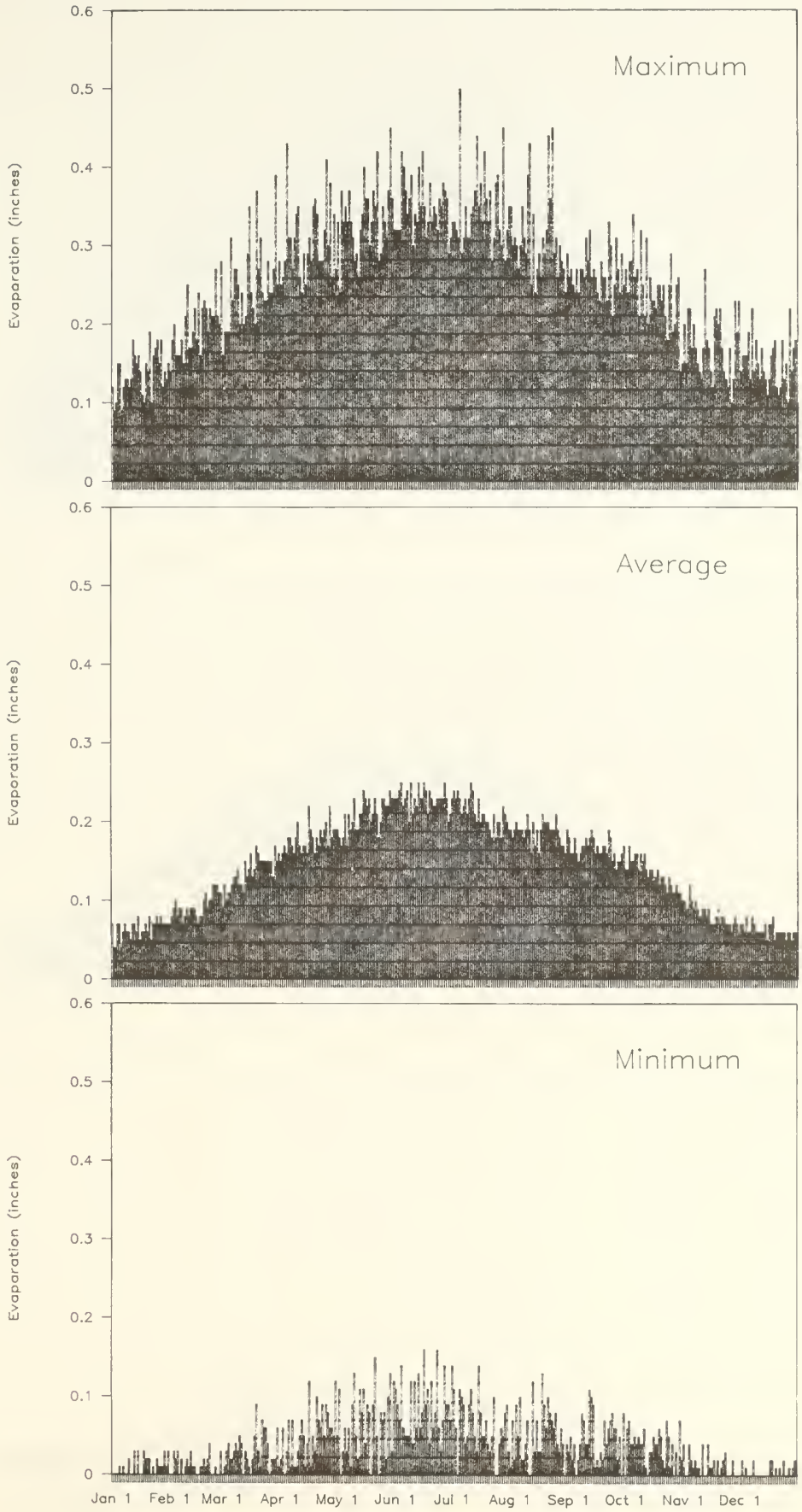

Figure 17. Average and extreme daily evaporation (inches), Fairhope, AL.

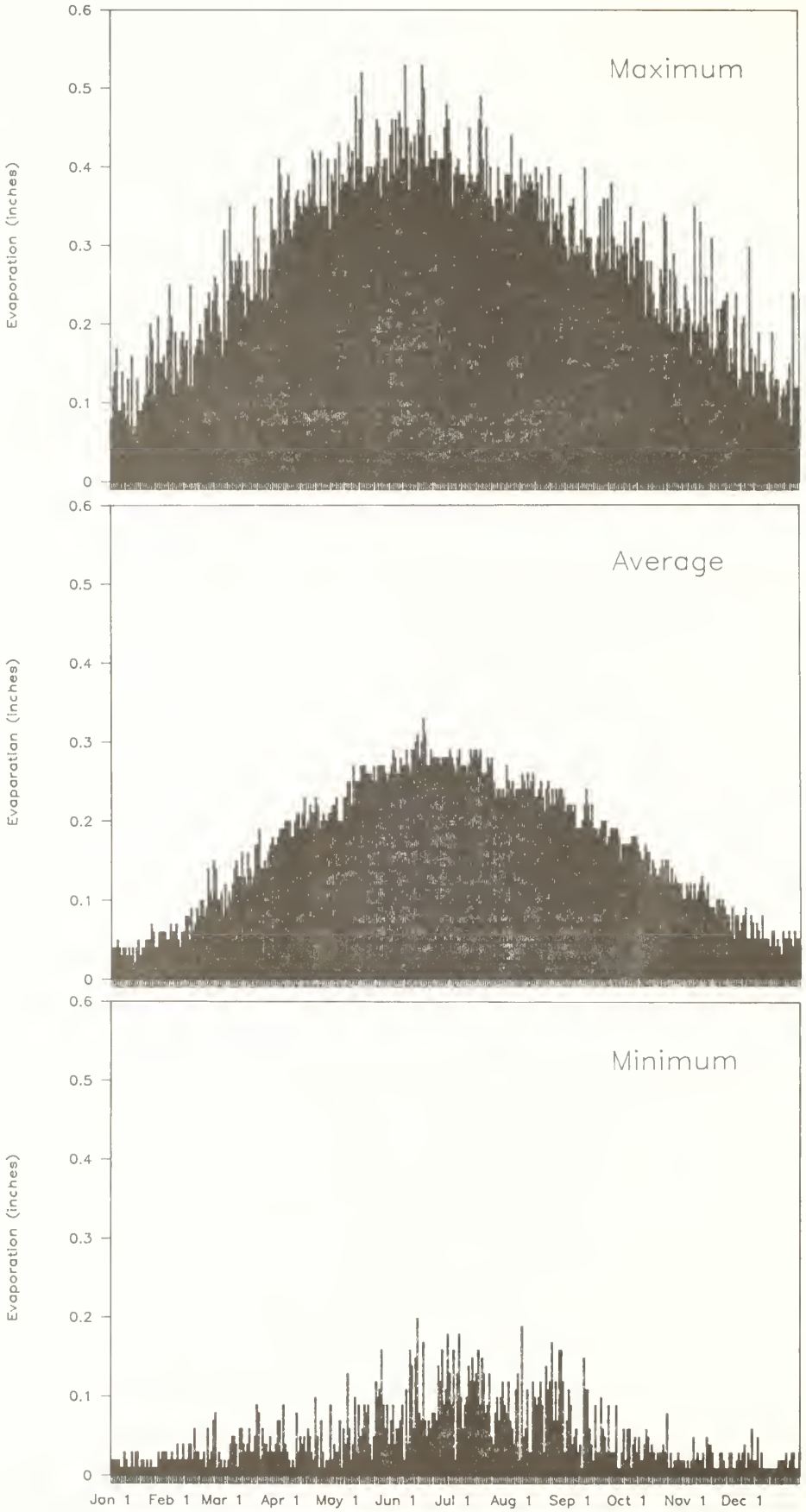

Figure 18. Average and extreme daily evaporation (inches), Stoneville, MS.

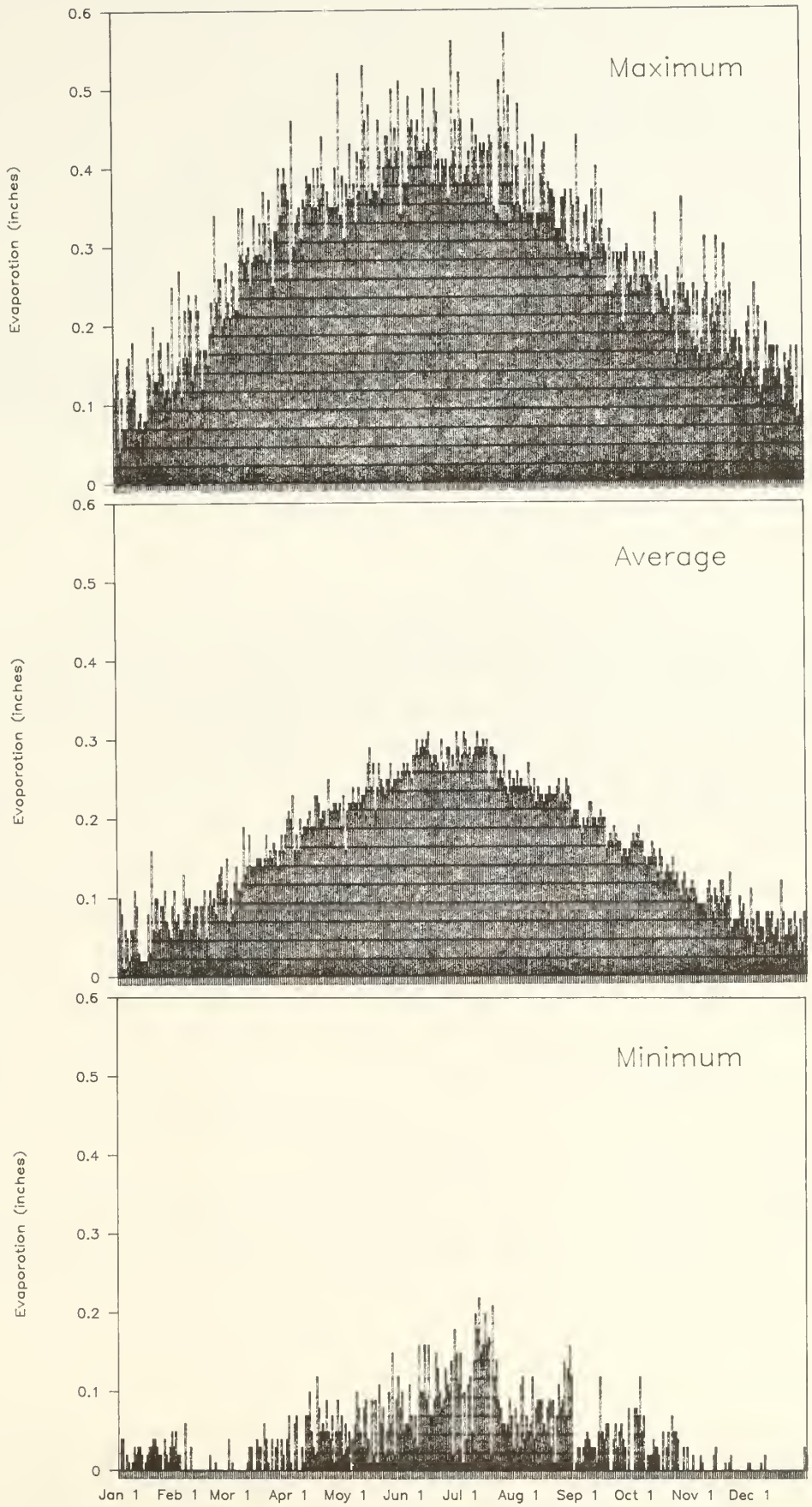

Figure 19. Average and extreme daily evaporation (inches), Stuttgart, AR.

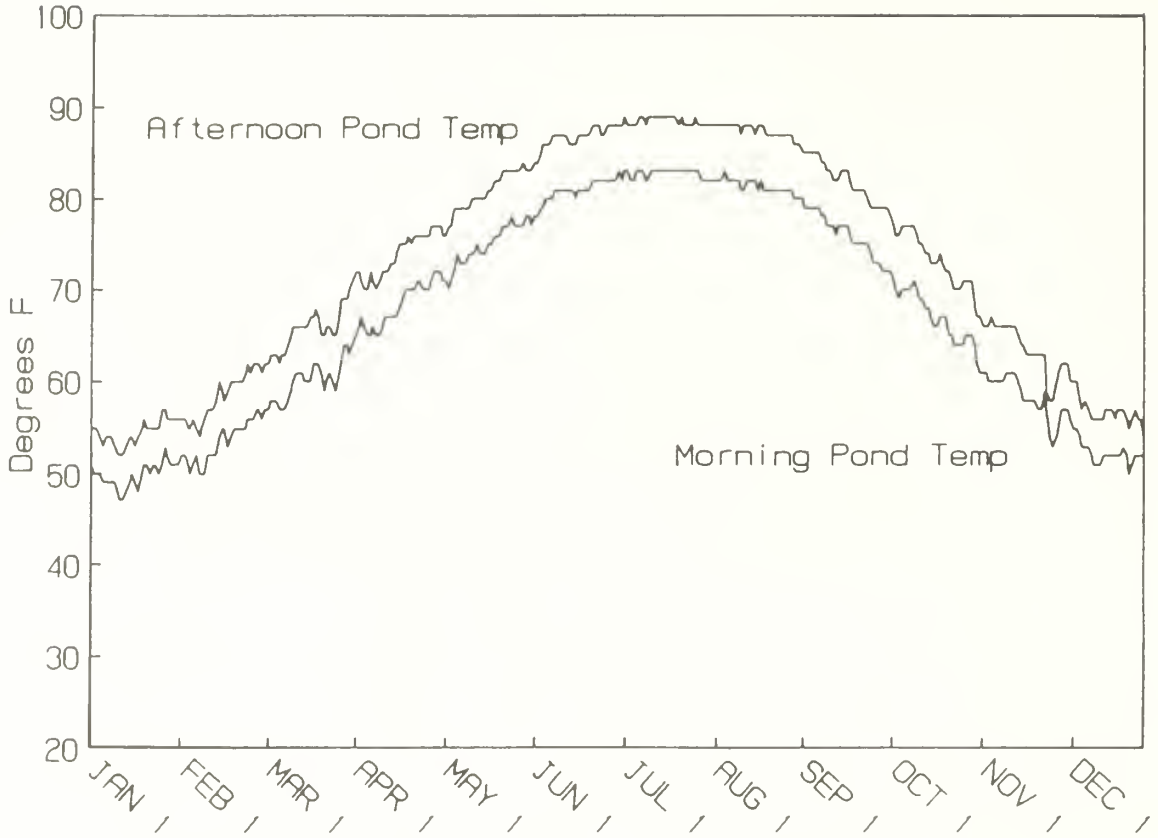

Figure 20. Average pond temperatures, Stoneville, MS.

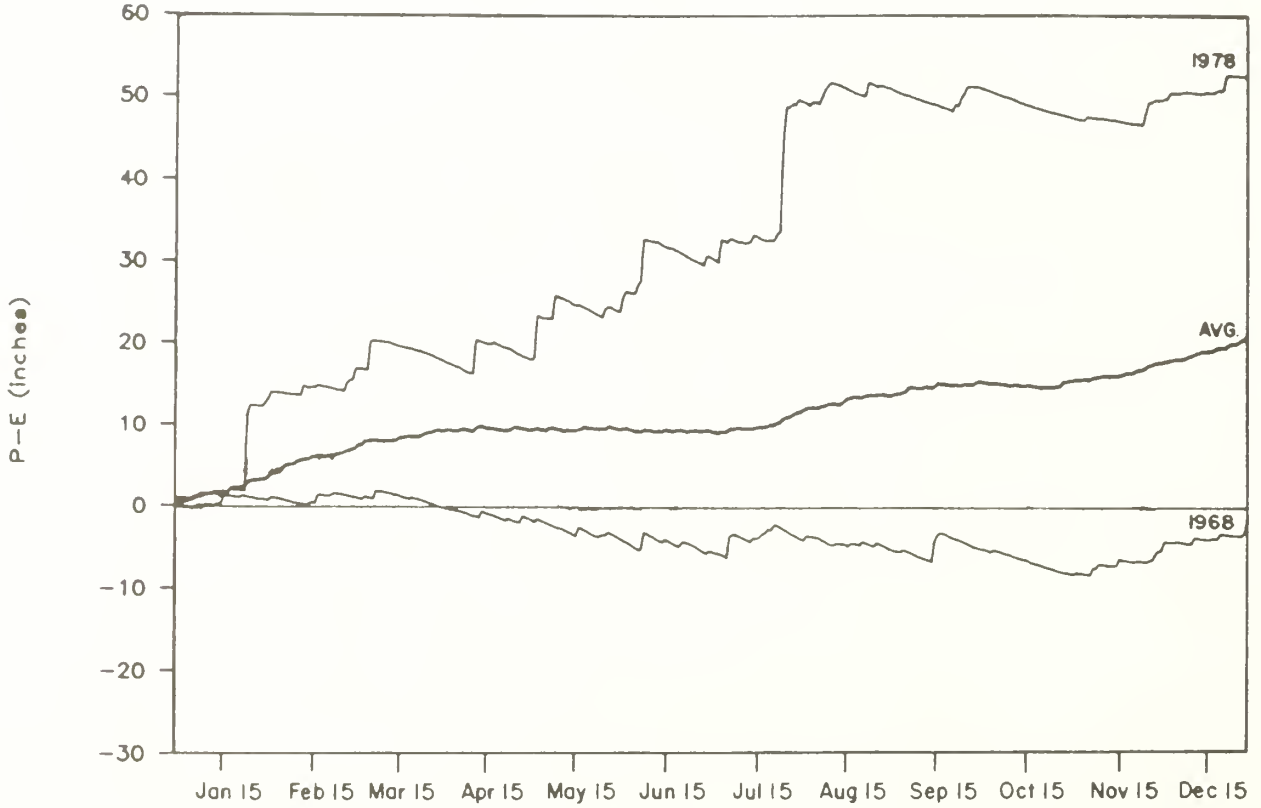

Figure 21. Cumulative P-E, daily, Fairhope, during the wettest year (1978), the driest year (1968), and the average year (average).

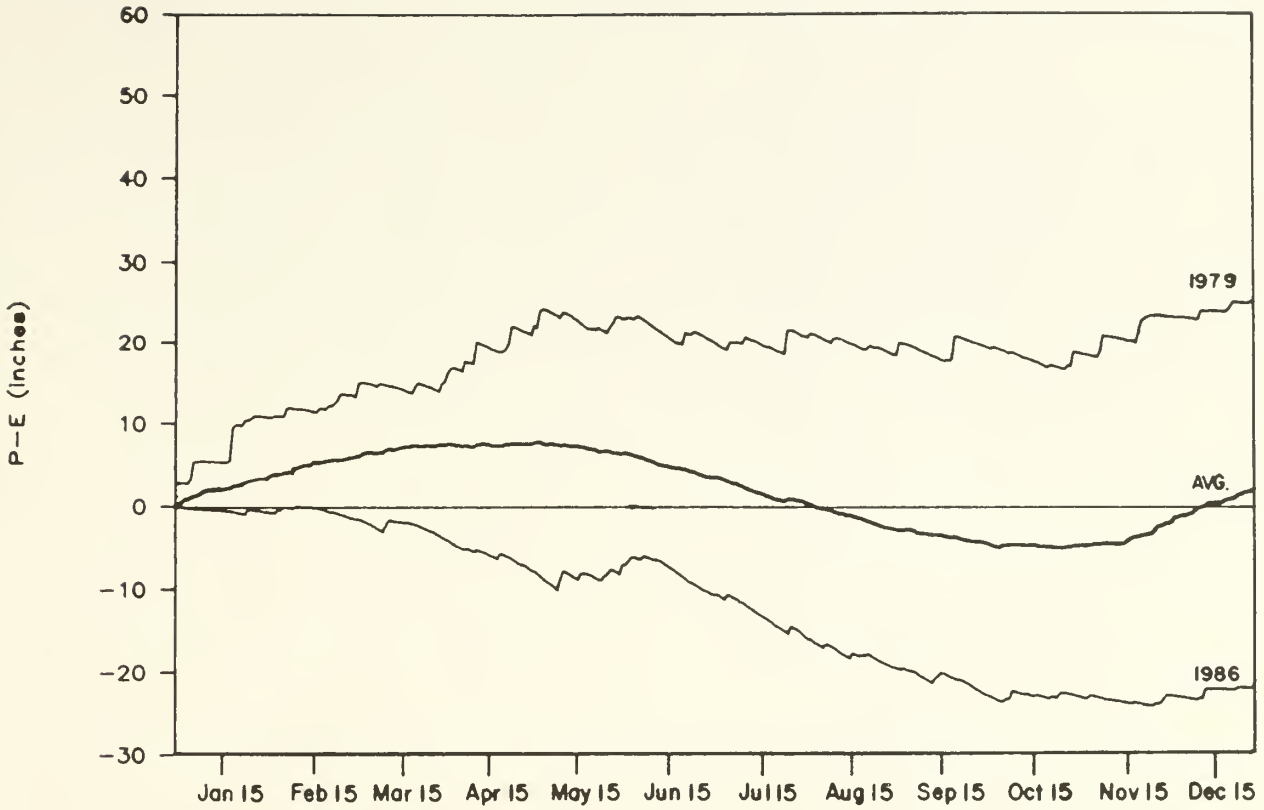

Figure 22. Cumulative P-E, daily, Stoneville, during the wettest year (1979), the driest year (1986), and the average year (average).

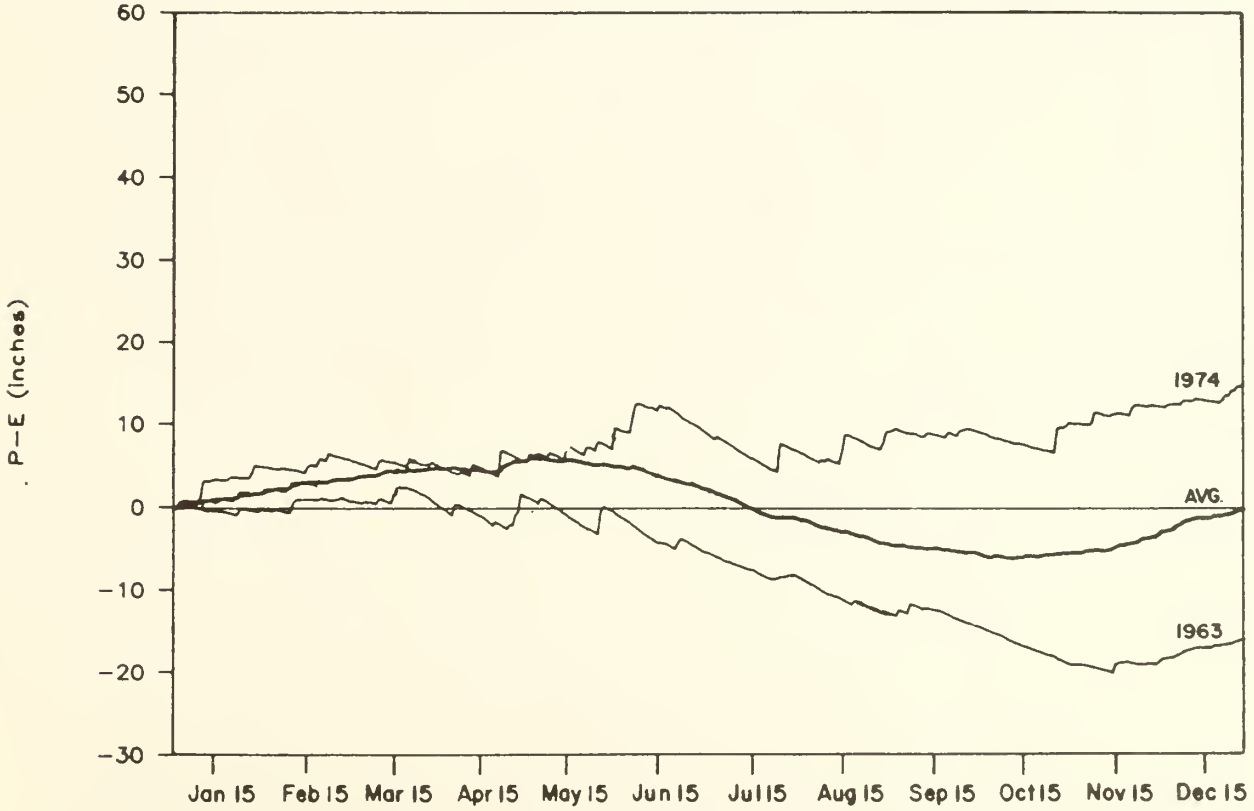

Figure 23. Cumulative P-E, daily, Stuttgart, during the wettest year (1974), the driest year (1963), and the average year (average).

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Bulletin 970 September 1990

Alicia Bermudagrass vs. Pensacola Bahiagrass

Economic Comparison of Intensive Cow–Calf Forage Systems for South Mississippi

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Alicia Bermudagrass vs. Pensacola Bahiagrass

Economic Comparison of Intensive Cow-Calf Forage Systems for South Mississippi

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Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine. Edited by Keith H. Remy, Publications Coordinator. Cover designed by Dale Jordan, Student Artist.

Economic Comparison of Intensive Cow-Calf Forage Systems for South Mississippi

Alicia bermudagrass and Pensacola bahiagrass are the two most common grasses for pasture and hay production in South Mississippi. The production, utilization and profitability of either grass is affected by numerous management practices. The purpose of this study was to compare their production and profitability in year-round cow-calf systems. Management, stocking rates, and fertilizer rates were held constant.

Experimental Procedures

Approximately 100 cows were calved each year in February and March of 1982, 1983, 1984, and 1985 (total of 389 calves). Data generated by these animals were used to compare the production and economics of two grazing systems (Alicia bermudagrass versus Pensacola bahiagrass) and creep feeding (creep feed versus forward grazing) in a 2 x 2 factorial in a randomized complete block design (years as blocks). Each grazing system consisted of 25 cows and calves on 25 acres. At birth, calves were weighed, identified, bull calves castrated, and calves were weaned in October.

Cows were balanced by breed (1/2 Angus, Brangus, Beefmaster, and Barzona x 1/2 Hereford and purebred Hereford) across both forage systems, but otherwise randomly assigned. Sire breeds (Brahman, Beefmaster, Barzona, Brangus, and Simbrah) of the calves were represented across both systems.

Each pasture was cross-fenced to permit three-way rotational grazing. Creep gates were installed in systems with forward grazing to allow calves free access to any of the three paddocks at any time. Systems with creep feeding had self-feeding calf creeps to allow *ad libitum* intake of a commercial pelleted creep ration. Excess summer forage was harvested as hay and hay yield (pounds/acre) was estimated by the number of large round bales. Two-thirds of each pasture system was overseeded with Marshall ryegrass in October using a no-till drill planter. Both winter and summer pastures were fertilized according to soil test recommendations. Only pesticides currently registered for use on pastures, hay fields, and beef cattle were used during the course of this study with strict adherence to all label instructions. A commercial salt-mineral mix was available *ad libitum*, and during winter grazing periods, a high magnesium mix was used.

During the first 60 days prepartum, cows were fed 25 pounds of hay per head per day and protein supplement. Initially, postpartum cows were allowed to limit graze ryegrass pastures when forage was available. When sufficient forage became available, cows and calves continuously grazed on ryegrass pastures.

Statistical analysis of data was done using GLM procedures from SAS. The linear model included year (as blocks), system, creep, system x creep interaction, and sex. The effects of year, system, creep, and system x creep interaction were tested with a pooled term error A (year x system x creep, 9 d.f.). Error B (year x system x creep x sex, 15 d.f.) was used to test effects of sex of calf. Year x system and year x creep interactions were tested in a preliminary analysis with all main effects included in the model so that, if they were not significant ($P<0.05$), they could be pooled in error A. Least squares means were computed for system, creep, sex, year x system, and year x creep.

Budgets were prepared for each forage system following the format used in the Farm Management Handbook published by the Agricultural Economics Department of the Mississippi Cooperative Extension Service. When actual income and expense figures were not available, assumptions were made to approximate the economic situation in South Mississippi. A major deviation from this format was in calculations for replacement cows because assumptions did not seem realistic.

Results and Discussion

The Alicia bermudagrass system produced more hay than the bahiagrass system (Table 1) under the management of this study. The amount of hay fed in the two systems was similar because the

Table 1. Hay yield and hay fed in cow-calf forage systems with Alicia bermudagrass and Pensacola bahiagrass. White Sand Unit of the MAFES South Mississippi Branch, 1982 - 1985.

Item	Unit	Year				Mean
		1982	1983	1984	1985	
Alicia						
Hay yield	tons/acre	2.41	1.16	1.68	1.11	1.59
Hay fed	tons/acre	1.14	1.67	0.93	0.62	1.09
Excess (deficit)	tons/acre	1.27	(0.51)	0.75	0.49	0.50
Bahia						
Hay yield	tons/acre	0.60	0.36	0.14	0.31	0.35
Hay fed	tons/acre	1.28	1.67	1.01	0.67	1.16
Excess (deficit)	tons/acre	(0.68)	(1.31)	(0.87)	(0.36)	(.81)

winter pastures and management were identical. Hay production exceeded hay feeding requirements in the Alicia bermudagrass system by approximately 0.5 ton per acre per year. However, years 1982, 1984, and 1985 had excess bermudagrass hay, and 1983 had deficit production. The bahiagrass system consistently produced less hay than was needed and, as a result, hay had to be purchased from outside the system. The mean hay deficit in the bahiagrass system was 0.8 ton per acre.

Calves in the bahiagrass system had a 21-pound heavier ($P<0.05$) adjusted 205-day weaning weight than calves in the Alicia bermudagrass system. A 17-pound advantage in actual weaning weight was not significant ($P=.07$, Table 2). Main effects of year, creep, and sex were significant for both adjusted and actual weaning weights. No two-way interactions were significant ($P<0.05$). Based on prevailing prices, this weaning weight advantage was negated by the bahiagrass system's hay deficit.

The Alicia bermudagrass system showed a net gain per cow (and per acre) of $40.46 compared to $9.82 for the Pensacola bahiagrass system — a difference of $30.64 in favor of bermudagrass (Tables 4 and 5). This difference is dependent on the year, prices, and/or other underlying assumptions. Calf weights in Table 2 were adjusted to give steer calves a 40-pound advantage over heifer calves. The advantage in steer calf weights should be greater than shown as it is common practice to save the heaviest heifer calves for replacements and sell the lightest.

Creep feeding increased weaning weights by 59 pounds over forward grazing. The economic advantage of creep feeding depends primarily upon feed conversion for added gain and the current calf prices (Table 3).

To adjust for price fluctuations, cattle prices used in the budgets were averaged over a 5-year period (1983-1988). Direct expenses listed in Tables 4 through 12 were for 1988 and 1989 in Poplarville, MS. Hay prices do not reflect differences in quality; thus, excess hay has the same value as purchased hay. The differences between Alicia bermudagrass and bahiagrass systems do not reflect fixed costs for establishment.

Fixed expenses for replacement cows were based upon a beef-forage management program used at the South Mississippi Branch Experiment Station since 1986. Heifers were calved as 2-year-olds and they were diagnosed pregnant with their second calf before being classified as mature cows. Most cow-calf budgets do not include a fixed expense for replacement females. Budgets in the Farm Management Handbook assume that (1) costs and income for first-calf cows are the same as for mature cows; (2) 15% of heifers are saved for replacement; (3) expenses for heifers are the same as mature cows; (4) no heifers are culled; and (5) conception rate of heifers is 100%.

In this study, when land areas for the cow herd and replacement females were combined, a total of 151.3 acres of pasture was required to support 100 head of mature cows. This assumes that 96% of cows that calved weaned a calf; that death rate was 1%; and that 15% of the cows were replaced each year. The 51.3 acres of land used for replacement females includes 18 acres of sod-seeded ryegrass for winter pasture that could be

Table 2. Least squares means of adjusted 205-day weaning weights and actual weaning weights in cow-calf forage systems comparing Alicia bermudagrass versus Pensacola bahiagrass. White Sand Unit of the MAFES South Mississippi Branch, 1982 - 1985.

		Year				
Item	Unit	1982	1983	1984	1985	Mean[a]
Alicia						
Adjusted 205-day WW	lb/hd	399	454	467	486	451x
Actual weaning weight	lb/hd	432	479	512	455	469
Bahia						
Adjusted 205-day WW	lb/hd	414	488	485	503	472y
Actual weaning weight	lb/hd	449	508	523	460	486

[a]Means in the same column with different letters are different ($P<0.05$).

Table 3. Least squares means of adjusted 205-day weaning weights and actual weaning weights in cow-calf forage systems comparing creep feeding versus forward grazing. White Sand Unit of the MAFES South Mississippi Branch, 1982 - 1985.

		Year				
Item	Unit	1982	1983	1984	1985	Mean[a]
Creep feeding						
Adjusted 205-day WW	lb/hd	431	501	506	519	489x
Actual weaning weight	lb/hd	467	529	549	482	507x
Forward grazing						
Adjusted 205-day WW	lb/hd	383	441	447	470	435y
Actual weaning weight	lb/hd	414	458	486	433	448y
Difference due to creep feeding						
Adjusted 205-day WW	lb/hd	48	60	59	49	54
Actual weaning weight	lb/hd	53	71	63	49	59
Creep feed consumed[b]	lb/hd	331	531	635	288	446
Feed conversion	ratio	6.25	7.48	10.08	5.88	7.56
Cost of feed[c]	$/hd	29.13	49.92	60.16	25.06	41.06
Cost of additional gain	$ /lb	.61	.70	.95	.51	.70

[a] Least squares means for type of creep in the same column with different letters are different ($P<0.05$).
[b] Creep feeding began 4/26/82, 5/1/83, 4/30/84, and 6/13/85.
[c] Commercial pelleted creep feed at $176 on in 1982, $188 on in 1983, $181 on in 1984, and $174 on in 1975.

used for hay production in the summer. Replacement female costs could be reduced from those shown in Table 6 by the value of hay sold.

The cost of producing replacement heifers was based on the assumptions that one-half of heifer calves weaned were retained as replacements and culled prior to breeding. At 15 months of age, 23% of the heifers were culled based on weight, frame size and/or pelvic area. Conception rate for heifers was 90%. Eighty percent of the first-calf cows rebred and were used as replacements in the mature cow herd. These assumptions were entered as input variables on an electronic spreadsheet that calculated whether or not sufficient heifers were retained to meet replacement needs. Using this tool, more or less animals can be kept to meet replacement needs. As more replacement heifers were saved and fewer culled prior to breeding, the cost per head for replacements decreased. Costs also decreased as conception rate for heifers and first-calf cows increased.

Summary

There was little economic difference between Alicia bermudagrass and Pensacola bahiagrass grazing systems for cow-calf production when stocked year round at one cow-calf unit per acre. Also, this study attempted to accurately calculate fixed costs for replacement females, a function not accomplished in most cattle budgets. These systems were designed for intensive land use and management. If fertilizer rates and/or stocking rates are changed, the results obtained from these forage systems may not be the same.

Table 4. Alicia bermudagrass forage system for cow-calf production in South Mississippi, estimated costs and returns of a 100-cow herd at a stocking rate of 1 head per acre[a].

Item	No. Head	Unit	Price ($)	Quantity	Amount ($)
INCOME					
Steer Calves	48	cwt	76.00	4.89	17,838.72
Heifer Calves	24	cwt	69.00	4.49	7,535.44
Cull Cows	14	cwt	40.00	10.00	5,600.00
Cull Bulls	1	cwt	47.00	15.00	705.00
Hay Sold[b]		ton	50.00	50.00	2,500.00
Total Income					34,079.16
DIRECT EXPENSES					
Summer Pasture[c]		acre	37.49	100.00	3,749.14
Sod-seeded Ryegrass Pasture[c]		acre	77.65	66.67	5,176.49
Hay Harvest-Pasture Clippings[bd]		ton	12.89	159.00	2,048.86
Hay Purchased[b]		ton	50.00	0.00	0.00
Protein Blocks, 500 lb		each	59.67	16.00	954.72
Salt and Minerals		cwt	13.00	24.00	312.00
Repairs on Buildings & Equipment[e]		year	306.14	1.00	306.14
Veterinary/Medicine		head	24.50	100.00	2,450.00
Interest on Operating Capital[f]		%	0.10	14,997.35	1,124.80
Marketing Cost		%	0.04	31,579.16	1,263.17
Labor		hour	5.00	485.00	2,425.00
Total Direct Expenses					19,810.32
RETURNS ABOVE DIRECT EXPENSES					14,268.84
RETURNS ABOVE DIRECT EXPENSES EXCLUDING LABOR					16,693.84
FIXED EXPENSES					
Depreciation and Interest					
Replacement Cows		head	342.57	15.00	5,138.55
Bull		head	1,240.00	1.00	1,240.00
Summer Pasture[c]		acre	2.34	100.00	234.00
Winter Pasture[c]		acre	5.62	66.67	374.67
Hay Harvest[d]		acre	9.73	159.00	1,547.07
Buildings & Equipment[e]		year	1,688.61	1.00	1,688.61
Total Fixed Expenses					10,222.90
TOTAL SPECIFIED EXPENSES					30,033.22
RETURNS ABOVE SPECIFIED EXPENSES					4,045.94
Per Cow (per acre)					40.46

[a] Assumptions for calculations: 96% calves weaned/cows calving, 1% death rate, 15% replacement rate, 50% heifers saved for replacement.
[b] Hay sold or purchased from Table 1.
[c] Summer and ryegrass pastures from Tables 7 and 8, respectively.
[d] Pasture clipping expenses from Table 10.
[e] Building and equipment expenses from Table 12.
[f] Interest on operating capital for 9 months.

Table 5. Pensacola bahiagrass forage system for cow-calf production in South Mississippi, estimated costs and returns for a 100-cow herd at a stocking rate of 1 head per acre[a].

Item	No. Head	Unit	Price ($)	Quantity	Amount ($)
INCOME					
Steer Calves	48	cwt	76.00	5.06	18,458.88
Heifer Calves	24	cwt	69.00	4.66	7,716.96
Cull Cows	14	cwt	40.00	10.00	5,600.00
Cull Bulls	1	cwt	47.00	15.00	705.00
Hay Sold		ton	50.00	0.00	0.00
Total Income					32,480.84
DIRECT EXPENSES					
Summer Pasture		acre	37.49	100.00	3,749.14
Sod-seeded Ryegrass Pasture		acre	77.65	66.67	5,176.49
Hay Harvest — Pasture Clippings		ton	12.89	35.00	451.01
Hay Purchased		ton	50.00	81.00	4,050.00
Protein Blocks, 500 lb		each	59.67	16.00	954.72
Salt and Minerals		cwt	13.00	24.00	312.00
Repairs on Buildings & Equipment		year	306.14	1.00	306.14
Veterinary/Medicine		head	24.50	100.00	2,450.00
Interest on Operating Capital		%	0.10	17,449.50	1,308.71
Marketing Cost		%	0.04	32,480.84	1,299.23
Labor		hour	5.00	485.00	2,425.00
Total Direct Expenses					22,482.44
RETURNS ABOVE DIRECT EXPENSES					9,998.40
RETURNS ABOVE DIRECT EXPENSES EXCLUDING LABOR					12,423.40
FIXED EXPENSES					
Depreciation and Interest					
Replacement Cows		head	342.57	15.00	5,138.55
Bull		head	1,240.00	1.00	1,240.00
Summer Pasture		acre	2.34	100.00	234.00
Winter Pasture		acre	5.62	66.67	374.67
Hay Harvest		acre	9.73	35.00	340.55
Buildings & Improvements		year	1,688.61	1.00	1,688.61
Total Fixed Expenses					9,016.38
TOTAL SPECIFIED EXPENSES					31,498.82
RETURNS ABOVE SPECIFIED EXPENSES					982.02
Per Cow (per acre)					9.82

[a]Assumptions and inputs are the same as for Table 4.

Table 6. Estimated annual costs and returns for replacement female production in South Mississippi, 15 head of replacements[a].

Item	No. Head	Unit	Price ($)	Quantity	Amount ($)
INCOME					
Cull Yearling Heifers	5	cwt	60.00	6.00	1,800.00
Cull 2-Yr Old Cows	3	cwt	40.00	9.00	1,080.00
Steer Calves	9	cwt	76.00	4.20	2,872.80
Heifer Calves	9	cwt	69.00	3.80	2,359.80
Total Income					8,112.60
DIRECT EXPENSES					
Ryegrass/Wheat Pasture[b]		acre	107.96	33.33	3,598.80
Sod-seeded Ryegrass Pasture[c]		acre	77.65	18.00	1,397.65
Millet Pasture[d]		acre	79.12	16.67	1,318.71
Hay Harvest — Alicia[e]		ton	52.13	29.50	1,537.98
Protein Block, 500 lb		each	59.67	2.88	171.85
Preconditioning Feed		ton	205.00	2.30	471.50
Mixed Feed, 12%		ton	180.60	3.45	623.07
Salt and Minerals		cwt	10.2	47.08	72.50
Veterinary/Medicine		head	21.00	41.00	861.00
Interest on Operating Capital[f]		%	0.10	10,053.07	753.98
Marketing Cost		%	0.04	2,880.00	324.50
Labor		hour	5.00	198.85	994.25
Total Direct Expenses					12,125.80
RETURNS ABOVE DIRECT EXPENSES					−4,013.20
RETURNS ABOVE DIRECT EXPENSES EXCLUDING LABOR					−3,018.95
FIXED EXPENSES (Depreciation and Interest)					
Bull		head	1,240.00	0.25	310.00
Ryegrass/Wheat Pasture[b]		acre	8.49	33.33	283.00
Overseeded Ryegrass Pasture[c]		acre	5.62	18.00	101.16
Millet Pasture[d]		acre	10.83	16.67	180.50
Hay Harvest — Alicia[e]		ton	8.50	29.50	250.69
Total Fixed Expenses					1,125.35
TOTAL SPECIFIED EXPENSES					13,251.15
SPECIFIED EXPENSES MINUS INCOME					5,138.55
Per cow (2.7-yr-old pregnant cow after weaning first calf)					342.57

[a] Assumptions: pregnancy rate for heifers 90%, pregnancy rate for first-calf cows 80%, 23 heifers weaned, 18 first-calf cows calving.

[b] From Table 9, stocked at 1.5 hd/acre for yearling heifers.

[c] From Table 8, stocked at 1 hd/acre for 2-yr-old cows.

[d] From Table 11, stocked at 3 hd/acre for yearling heifers and 2 hd/acre for 2-yr-old cows.

[e] High quality hay produced on land area designated for replacement female production. There is potential to sell hay from this land.

[f] Interest on operating capital for 9 months.

Table 7. Costs per acre for summer pasture maintenance, Alicia bermudagrass and Pensacola bahiagrass, South Mississippi, 1989.

Item	Unit	Price ($)	Quantity	Amount ($)
DIRECT EXPENSES				
Fertilizer (Spread)				
Lime	ton	30.00	0.33	9.90
Ammonium Nitrate (34% N)	cwt	9.25	2.00	18.50
Phosphate (46% P_2O5)	cwt	11.40	0.40	4.56
Potash (60% K_2O)	cwt	8.95	0.20	1.79
Operator Labor				
Tractors	hour	5.00	0.20	1.00
Diesel Fuel				
Tractors	gal	0.77	0.82	0.63
Repair & Maintenance				
Tractors	acre	0.47	1.00	0.47
Implements	acre	0.64	1.00	0.64
Total Direct Expenses	$/acre			37.49
FIXED EXPENSES (Depreciation and Interest)				
Tractors	acre	1.15	1.00	1.15
Implements	acre	1.19	1.00	1.19
Total Fixed Expenses	$/acre			2.34
TOTAL SPECIFIED EXPENSES	$/acre			39.83

Table 8. Costs per acre for ryegrass pasture, sod-seeded, South Mississippi, 1989.

Item	Unit	Price ($)	Quantity	Amount ($)
DIRECT EXPENSES				
Fertilizer (Spread)				
Ammonium Nitrate (34% N)	cwt	9.25	4.00	37.00
Phosphate (46% P_2O_5)	cwt	11.40	1.20	13.68
Potash (60% K_2O)	cwt	8.95	1.20	10.74
Seed				
Marshall Ryegrass Seed	lb	0.27	35.00	9.45
Operator Labor				
Tractors	hour	5.00	0.60	3.00
Diesel Fuel				
Tractors	gal	0.77	1.62	1.25
Repair & Maintenance				
Tractors	acre	0.93	1.00	0.93
Implements	acre	1.60	1.00	1.60
Total Direct Expenses	$/acre			77.65
FIXED EXPENSES (Depreciation and Interest)				
Tractors	acre	2.08	1.00	2.08
Implements	acre	3.54	1.00	3.54
Total Fixed Expenses	$/acre			5.62
TOTAL SPECIFIED EXPENSES	$/acre			83.27

Table 9. Costs per acre for Marshall ryegrass/wheat pasture, prepared seedbed, South Mississippi, 1989.

Item	Unit	Price ($)	Quantity	Amount ($)
DIRECT EXPENSES				
Fertilizer (Spread)				
Lime BL	ton	30.00	0.33	9.90
Ammonium Nitrate (34% N)	cwt	9.25	5.00	46.25
Phosphate (46% P_2O_5)	cwt	11.40	1.20	13.68
Potash (60% K_2O)	cwt	8.95	1.20	10.74
Seed				
Marshall Ryegrass Seed	lb	0.27	20.00	5.40
Wheat Seed	lb	0.12	90.00	10.80
Operator Labor				
Tractors	hour	5.00	0.97	4.85
Diesel Fuel				
Tractors	gal	0.77	3.33	2.56
Repair & Maintenance				
Tractors	acre	1.89	1.00	1.89
Implements	acre	1.89	1.00	1.89
Total Direct Expenses	$/acre			107.96
FIXED EXPENSES (Depreciation and Interest)				
Tractors	acre	4.49	1.00	4.49
Implements	acre	4.00	1.00	4.00
Total Fixed Expenses	$/acre			8.49
TOTAL SPECIFIED EXPENSES	$/acre			116.45

Table 10. Costs per acre for hay harvest of pasture clippings, 1 ton/acre per cutting, South Mississippi, 1989.

Item	Unit	Price ($)	Quantity	Amount ($)
DIRECT EXPENSES				
Other				
Twine	bun	17.89	0.04	0.75
Operator Labor				
Tractors	hour	5.00	0.90	4.50
Diesel Fuel				
Tractors	gal	0.77	2.65	2.04
Repair & Maintenance				
Tractors	acre	1.45	1.00	1.45
Implements	acre	4.15	1.00	4.15
Total Direct Expenses	$/acre			12.89
FIXED EXPENSES (Depreciation and Interest)				
Tractors	acre	3.29	1.00	3.29
Implements	acre	6.44	1.00	6.44
Total Fixed Expenses	$/acre			9.73
TOTAL SPECIFIED EXPENSES	$/acre			22.62

Table 11. Costs per acre for Tifleaf millet pasture, South Mississippi, 1989.

Item	Unit	Price ($)	Quantity	Amount ($)
DIRECT EXPENSES				
Fertilizer (Spread)				
Ammonium Nitrate (34% N)	cwt	9.25	3.50	32.38
Phosphate (46% P_2O_5)	cwt	11.40	1.20	13.68
Potash (60% K_2O)	cwt	8.95	1.20	10.74
Seed				
Tifleaf Millet Seed	lb	0.28	30.00	8.40
Operator Labor				
Tractors	hour	5.00	1.17	5.85
Diesel Fuel				
Tractors	gal	0.77	4.15	3.20
Repair & Maintenance				
Tractors	acre	2.36	1.00	2.36
Implements	acre	2.52	1.00	2.52
Total Direct Expenses	$/acre			79.12
FIXED EXPENSES (Depreciation and Interest)				
Tractors	acre	5.64	1.00	5.64
Implements	acre	5.19	1.00	5.19
Total Fixed Expenses	$/acre			10.83
TOTAL SPECIFIED EXPENSES	$/acre			89.95

Table 12. Annual costs for buildings, equipment, and improvements for cows, bulls and replacement females, 133 acres and six fields.

Item	Cost ($)	Unit	Life (Yr)	Amt. Req'd	Invest. Req'd ($)	Repair (%)	Repair Costs ($)	Annual Deprec. ($)
Fencing, Electric	1,000.00	mi	20	3.4	3,369	50	84.23	168.45
Charger, Misc.	688.00	ea	10	1.0	688	50	34.40	68.80
Gates	48.39	ea	10	7.0	339	50	16.94	33.87
Corral	3,000.00	ea	10	1.0	3,000	50	150.00	300.00
Hay Rings	97.00	ea	10	6.0	582	10	5.82	58.20
Feed Trough	167.95	ea	5	2.0	336	10	6.72	67.18
Water Trough	133.95	ea	10	6.0	804	10	8.04	80.37
Total					9,117.00		306.14	776.88
Interest on Investment					10%			911.74
Fixed Costs								1,688.61
Direct Costs								306.14
Per Head Fixed Costs								16.89
Per Head Direct Costs								3.06
							Total	19.95

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Bulletin 971
January 1991

FORESTRY AND MISSISSIPPI'S FOREST RESOURCES

THEIR ECONOMIC IMPORTANCE

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MISSISSIPPI AGRICULTURAL & FORESTRY EXPERIMENT STATION Verner G. Hurt, Director Mississippi State, MS 39762
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Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine. Edited by Keith H. Remy, Publications Coordinator. Cover designed by Betty Mac Wilson, Artist.

Acknowledgments

The authors are indebted to many individuals for their assistance with this publication. Those individuals contributing to the publication include: John Kelly, Research Forester, and John Vissage, Forester, USDA Forest Service, Southern Forest Experiment Station, Starkville, MS; Bill Colvin, Information and Education Director, and Randal Romedy, Utilization and Marketing Forester, Mississippi Forestry Commission, Jackson, MS; Dr. Daniel K. Lee, Director, Division of Economics, Institutions of Higher Learning, Jackson, MS; Bruce Alt, Division Forester, American Pulpwood Association Incorporated, Jackson, MS; Michael Webb, R.F., A.C.F., Webb Forestry Consultants, Columbia, MS; Julie Marcy, Environmental Specialist, U.S. Army Corp of Engineers, Vicksburg District, Vicksburg, MS; and Doug Williams, former Public Affairs Officer, Mississippi National Forests, Jackson, MS.

This publication benefited greatly from critical reviews conducted by Dr. Douglas Richards, Head; Dr. Keith Belli, Assistant Professor; Dr. Steven Bullard, Associate Professor; Dr. Dennis Cengel, Assistant Professor; and Dr. G. H. Weaver, Associate Professor, Department of Forestry, Mississippi State University; and Keith Remy, Publications Coordinator, Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine, Mississippi State University. The authors remain solely responsible for contents of the final publication.

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Forestry and Mississippi's Forest Resources — Their Economic Importance

Introduction and Highlights

This bulletin provides an overview of Mississippi's forest resources and forestry's contribution to the Mississippi economy. Forest resources cover almost 17 million acres of Mississippi, and forestry is a vital component of the state's economy. Everything concerning forestry and forest resources cannot be covered in one publication. However, the breadth of this overview should provide the reader with an appreciation for the vast range of benefits derived from Mississippi's extensive forest resource.

Mississippi's Forest Industry

Mississippi's forest industry is one of the driving forces of the state's economy. Raw materials from the state's timberlands support the production of lumber, plywood, wood pulp, paper, furniture and many other semi-finished and finished forest products. Some examples of the industry's importance in Mississippi's economy include the following:

- Forest industries own or control 20 percent—3.2 million acres—of Mississippi's timberland.
- Almost 1.9 billion board feet of sawtimber and more than 7.2 million cords of pulpwood were harvested from Mississippi's timberland in 1989.
- The value of Mississippi's forest products at first delivery point totaled $717 million in 1989, and exceeded that of any single agricultural crop.
- In 1988, approximately 57,000 Mississippians earned over one-billion dollars in wages while employed by the forest industry. Furthermore, almost one of every four manufacturing jobs and dollars of wages paid are provided by the forest industry.
- In 1986, more than $1.8 billion of processing value was added by Mississippi's forest industry.
- The value of Mississippi's forest products exported to foreign markets totaled $565 million in 1986, and accounted for almost 13 percent of all of the state's forest industry shipments.
- During 1988, Mississippi was a net exporter of pulpwood to neighboring states for wood pulp processing and further paper manufacturing. Using economic multipliers, net pulpwood exports of 3.1 million cords in 1988 would have supported an additional $2.1 billion of output, $361 million in annual income, and 16,364 more jobs in Mississippi's total economy. Furthermore, an additional $43 million would have been generated for the state's government revenues through increased economic activity.

Forestry and the Mississippi Economy

Economic multipliers of Mississippi's forest industry demonstrate a strong relationship to the state's economy. The strength of the relationship results from forest industry's close ties to other state industries and Mississippi's vast timberlands. The following are examples of economic impacts resulting from Mississippi's forest industry:

- A $1.00 increase in output from Mississippi's forest industry will stimulate $1.06 of production and sales in other state industries.
- A $1.00 increase in income in Mississippi's forest industry will result in $0.96 of additional household income in the state's total economy.
- For each additional job created in Mississippi's forest industry, 1.23 jobs will be created in other state industries.
- Evaluation of a weighted-Type II economic multiplier indicates that the forest industry has the greatest impact on Mississippi's economy of any manufacturing industry in the state.

Mississippi's Forest Resources

Forests cover 56 percent of the state's land and are well-distributed throughout Mississippi except in the Delta. In the last 30 years, Mississippi's commercial timberland acreage has remained relatively stable, although changes have occurred from region to region within the state. The following are some of the highlights of Mississippi's forest resources.

- Forests occupy 56 percent—17 million acres—of Mississippi's land area.
- Almost 70 percent—11.7 million acres—of Mississip-

pi's timberlands are in nonindustrial private ownership.

- Current growth of Mississippi's timberlands is only 46 percent of the potential for fully-stocked natural stands.
- Forest industry ownerships account for 53 percent—1.2 million acres—of the pine and oak-pine plantations in Mississippi.
- Since 1957, timber volumes on the state's timberlands have almost doubled. However, in 1987, timber volumes for Mississippi's softwood growing stock were essentially unchanged from 1977, while hardwood growing stock continued to increase.
- Mississippi's softwood timber growth approximately equals softwood timber removals, while hardwood timber growth is approximately twice that of hardwood timber removals.

Nonindustrial Private Forest Landowners

Ownership patterns have shaped the characteristics of the state's timberland resource. Thus, the future of Mississippi's timberland resource largely depends on the management practiced on the 11.7 million acres of timberland controlled by nonindustrial private forest (NIPF) landowners. Characteristics of these landowners influence the level of timber management practiced, which, in turn, affects the future supply of forest products. Some characteristics of these landowners and the impact they provide include the following:

- NIPF landowners control nearly 70 percent—11.7 million acres—of Mississippi's timberland.
- More than 70 percent of NIPF land is held by owners who control 100 acres or more.
- The more timberland a NIPF landowner controls, the more apt he is to sell timber.
- Nearly 70 percent of NIPF land in Mississippi is owned by individuals or individuals and their spouses.
- Well over one-half of Mississippi's NIPF land is owned by persons aged 55 or older.
- More than 70 percent of NIPF timberland belongs to owners primarily interested in either current or future income.
- Only 18 percent of NIPF land in Mississippi is covered by a written management plan.

Mississippi's Public Forest Resources

Mississippi's public forest resources are well-distributed throughout the state. These resources are managed by various government agencies to fulfill a diverse set of objectives. Many of the public forest resources provide opportunities for outdoor recreation and wildlife management, along with the production of forest products. Some of the highlights of Mississippi's public forest resources include the following:

- Forest resources administered by the USDA Forest Service, U.S. Army Corps of Engineers, USDI Fish and Wildlife Service, and the Mississippi Department of Wildlife , Fisheries, and Parks account for approximately 1.4 of the estimated 1.9 million acres of public timberlands in Mississippi.
- Approximately 25 million visitor-days of recreational activities were enjoyed on Mississippi's public forests and their associated water facilities in 1988.
- Wildlife objectives are the primary management emphasis for several of Mississippi's public forest resources and play an integral role in the remainder of the state's public forests.
- In 1988, more than 7 million man-days were spent in hunting activities; an additional 1.5 million man-days are spent in non-consumptive wildlife activities each year in Mississippi on both public and private lands.

Mississippi's Forest Industry

Utilization of Mississippi's forest resources began with early settlement. In 1840, almost 120,000 cords of fuelwood were sold primarily to steamboats operating on the Mississippi River (Williams, 1980). More than 300 sawmills were operating in Mississippi in 1840, and forest industry continued to expand through the 1800's as settlement of the state progressed.

An explosive expansion began shortly after the turn of the century, and by 1925, the state's peak year for lumber production, almost 40,000 workers were employed in forest industries (James 1951). Today, the industry continues to be a major component of Mississippi's economy.

Forest Industry Timberland Ownership

Mississippi's forests possess and grow the raw material required by the state's forest industry. This industry owns or controls approximately 3.2 million acres of Mississippi's timberland. The forest industry consists of almost 800 primary and secondary processing facilities dispersed throughout the state. However, the industry's timberland ownership is highly concentrated. Six companies account for almost 86 percent of the estimated forest industry timberland ownership (Table 1). Additionally, forest industry timberland ownership is most heavily concentrated in the southern one-third and the east-central areas of Mississippi (Figure 1).

Forest Products and Production

Raw materials from Mississippi's forests are produced in various forms for various uses. Total production of pine and hardwood sawtimber in the form of sawlogs, plywood logs, poles, piling, veneer logs, and crossties harvested from the state's forests increased from approximately 1 billion board feet in 1982, to almost 1.9 billion board feet in 1989 (Figure 2)[1]. In 1989, combined pine and hardwood sawtimber pro-

[1] When appropriate, supporting tables for figures can be found in Appendix A.

Table 1. Area of timberland owned in simple fee or controlled through long-term lease agreements by forest industries, Mississippi, 1989.[1]

Industry Name	Area of timberland
	(acres)
Georgia-Pacific Corporation	940,000
International Paper Company	902,000
Weyerhauser Company	402,000
Cavenham Forest Industries Inc.	289,000
Scott Paper Company	195,000
Packaging Corporation of America	134,000

[1] Based on an informal survey of forestry managers conducted by the authors. Actual figures may vary at any point in time based on each firm's timberland acquisition and disposal activities. Georgia-Pacific's timberland area includes that acquired from Leaf River Forest Products in 1990.

The Newsprint South, Inc. mill, located in Grenada, Mississippi, opened in September 1989. The mill, which employs 220 people, produces high quality newsprint from southern pine timber grown in northeastern Mississippi.

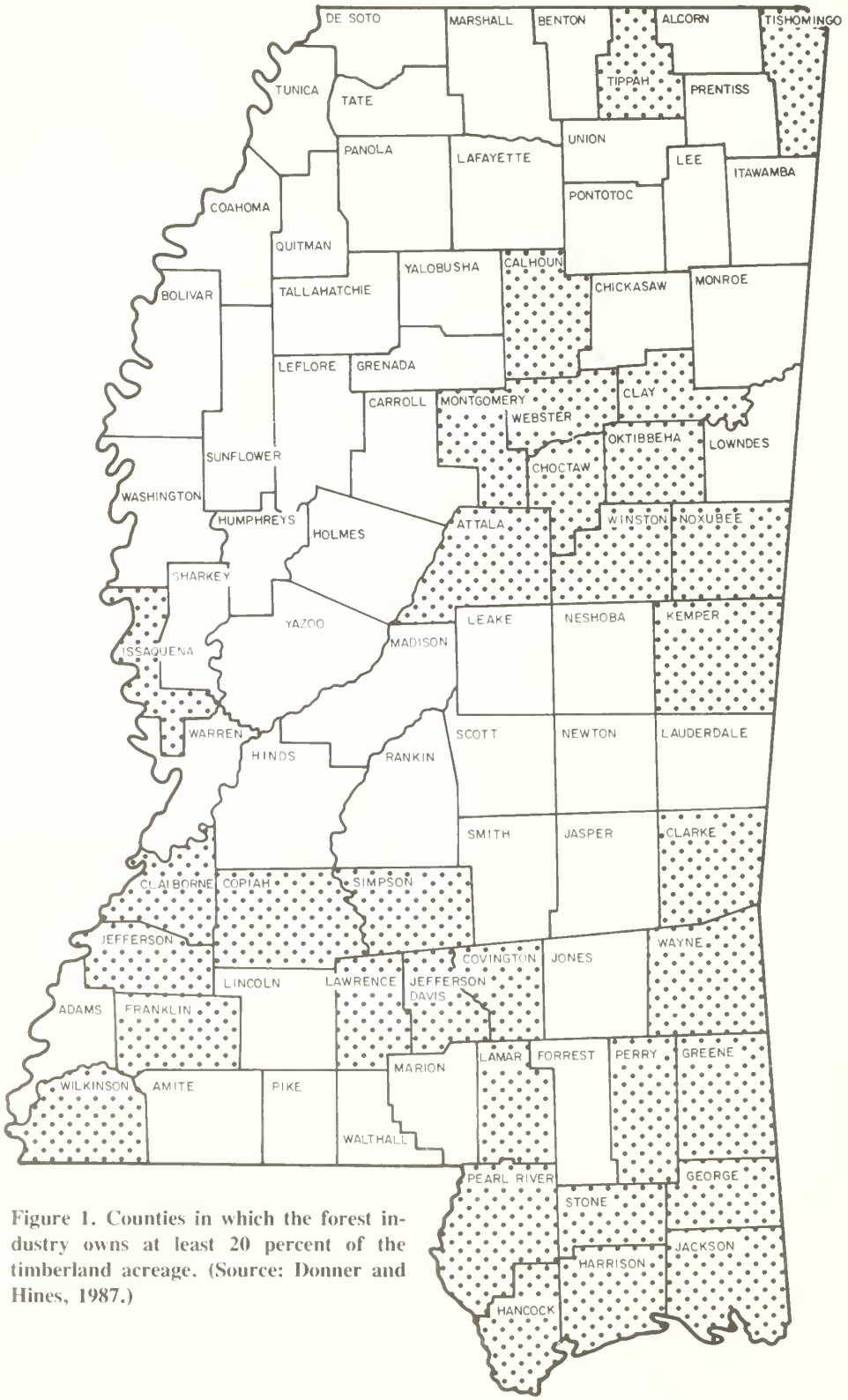


Figure 1. Counties in which the forest industry owns at least 20 percent of the timberland acreage. (Source: Donner and Hines, 1987.)

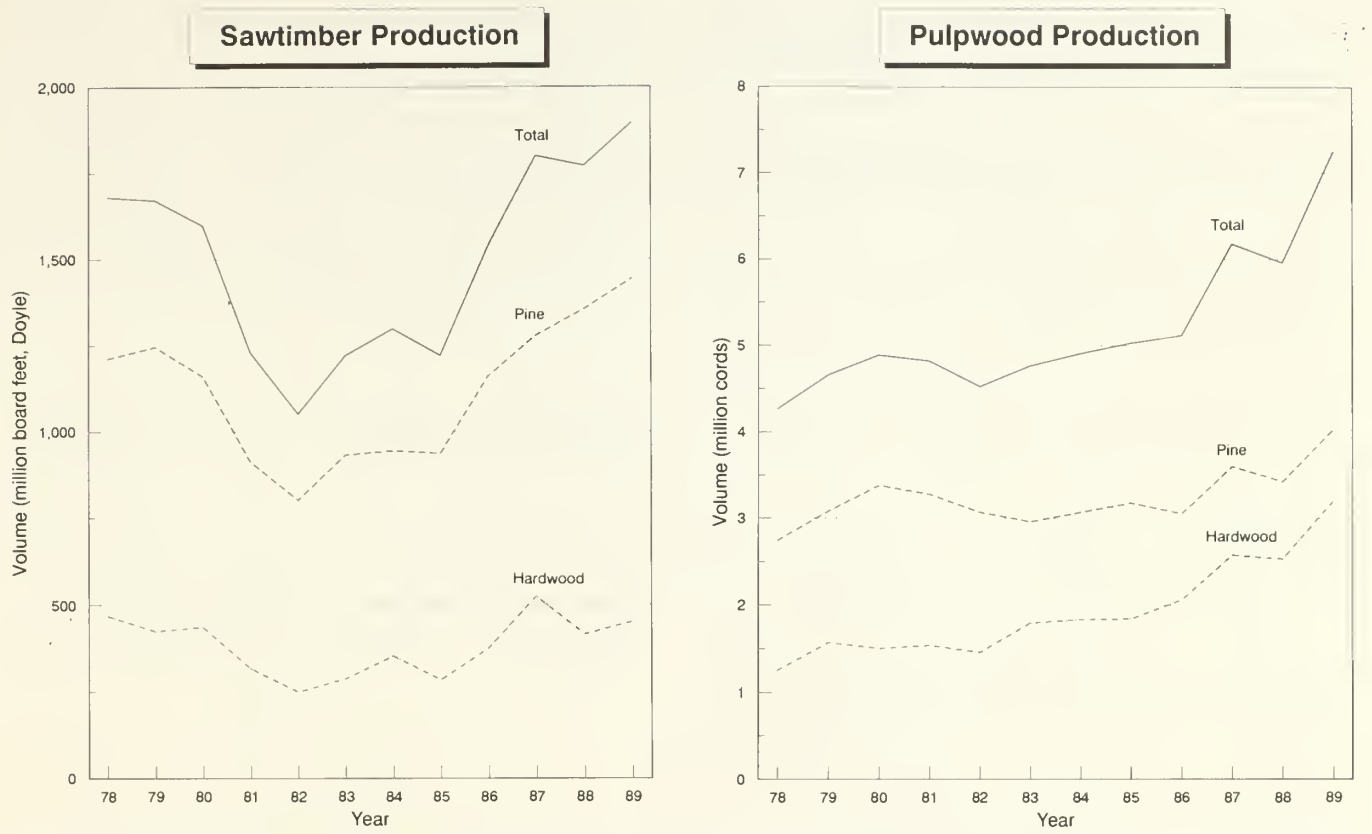


Figure 2. Forest production in Mississippi by product class and species group, 1978-1989. (Source: Mississippi Cooperative Extension Service—Annual.)

duction was 7 percent more than it was in 1988, with pine sawtimber comprising 76 percent of all sawtimber production.

Combined production of pine and hardwood pulpwood harvested from the state's forests for the manufacture of wood pulp, chip-n-saw, and other uses increased from 4.5 million cords in 1982 to more than 7.2 million cords in 1989 (Figure 2). Between 1988 and 1989, total pulpwood production increased almost 1.3 million cords—22 percent—as both pine and hardwood production increased.

The hardwood component of total pulpwood production increased from 31 percent in 1980 to 44 percent in 1989. New technological processes now allow hardwood usage in panel products such as oriented strand board. These products are consumed, in some instances, as substitutes for softwood plywood. Technological and product line changes in the pulp and paper industry have also increased hardwood usage. Furthermore, emergence of foreign markets for hardwood chips has increased demand for hardwood pulpwood. For these reasons, Mississippi's hardwood resource will become an increasingly important source of fiber.

Pulpwood Production and Consumption

Pulpwood production, in the form of roundwood and wood chips harvested from Mississippi's forests, and wood chips from wood-using industry residues, are consumed by pulp mills located in Mississippi and surrounding states for the manufacture of wood pulp. Pulpwood production data are reported annually (USDA Forest Service — Annual) as are data for Mississippi's consumption of pulpwood for wood pulp and energy (American Pulpwood Association — Annual).

The American Pulpwood Association (APA) uses the term *"wood fiber"* to describe pulpwood in its reports. In this report, the term *"pulpwood"* is used to be consistent with other data sources. APA data consolidate pulpwood consumed domestically for the manufacture of wood pulp and energy, however, energy components of pulpwood consumption are not available each year because of disclosure restrictions. Nevertheless, 618,000 cords of pulpwood were consumed for energy in Mississippi during 1988. Differences between Mississippi's pulpwood production and consumption, using USDA Forest Service and APA data, are therefore a close proxy in the determination of whether Mississippi is a net exporter or importer of pulpwood destined for domestic wood pulp production.

It is apparent from Figure 3 that Mississippi is a net exporter of pulpwood. From 1977 to 1988, annual production and consumption of pulpwood have fluctuated, but annual differences have varied around the 2 million cord level. Moreover, differences between pulpwood production and consumption for the manufacture of wood pulp are actually greater than indicated in Figure 3 since energy components

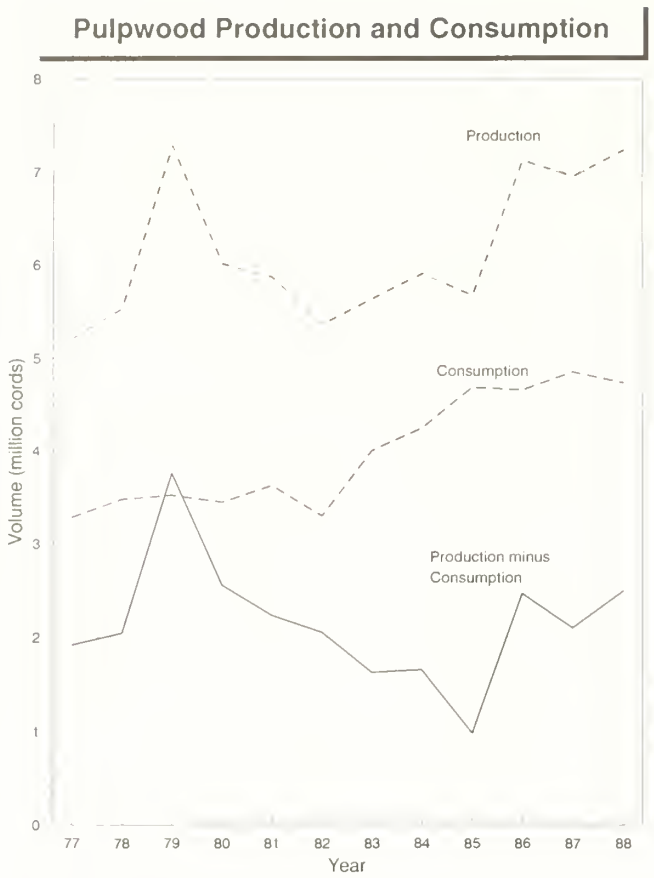


Figure 3. Mississippi pulpwood production and consumption, 1977-1988. (Sources: USDA Forest Service—Annual; American Pulpwood Association—Annual.)

of consumption cannot consistently be separated from totals. Additionally, pulpwood production data do not include roundwood and wood chips harvested from Mississippi's forests and exported to foreign markets.

In 1988, 7.2 million cords of pulpwood were produced and 4.7 million cords of pulpwood were consumed in Mississippi. Of the 4.7 million cords consumed, 618,000 were for the manufacture of energy. Thus, 4.1 million cords of pulpwood were consumed in the state for the manufacture of wood pulp during 1988. Therefore, approximately 3.1 million cords of pulpwood were apparently exported to Mississippi's domestic neighbors for the manufacture of wood pulp in 1988.

Mississippi's annual pulpwood consumption was relatively constant from 1977 to 1982. However, it increased from 1982 to 1988. Although Mississippi's annual consumption has been increasing, the 2 million cord differential between production and consumption is still being maintained. New pulp mill construction and expansions will continue to increase wood pulping capacity within the state, resulting in increased pulpwood production and consumption.

Value of Agricultural Crops and Forest Products

The $717 million value of forestry harvests in 1989 is the largest ever recorded in the state and exceeds that of any single agricultural crop (Figure 4). Almost every forestry product harvested in Mississippi increased in value from 1988 to 1989. Furthermore, of the $717 million of total value, landowners received $410 million as payments for stumpage, or 57 percent of the value of forestry products harvested. The remaining 43 percent represented the value of harvesting and transporting material to the point of first delivery.

The value of forest products at first delivery point underestimates the impact of forestry on Mississippi's economy. Indeed, forest-based manufacturing facilities are attracted to the state because sawlogs and pulpwood are relatively heavy and, thereby, costly to transport. These manufacturing facilities further increase the impact of forestry through additional employment and wages. Conversely, commodities such as cotton and soybeans are predominately exported from the state for processing, thus effectively reducing their additional value to Mississippi.

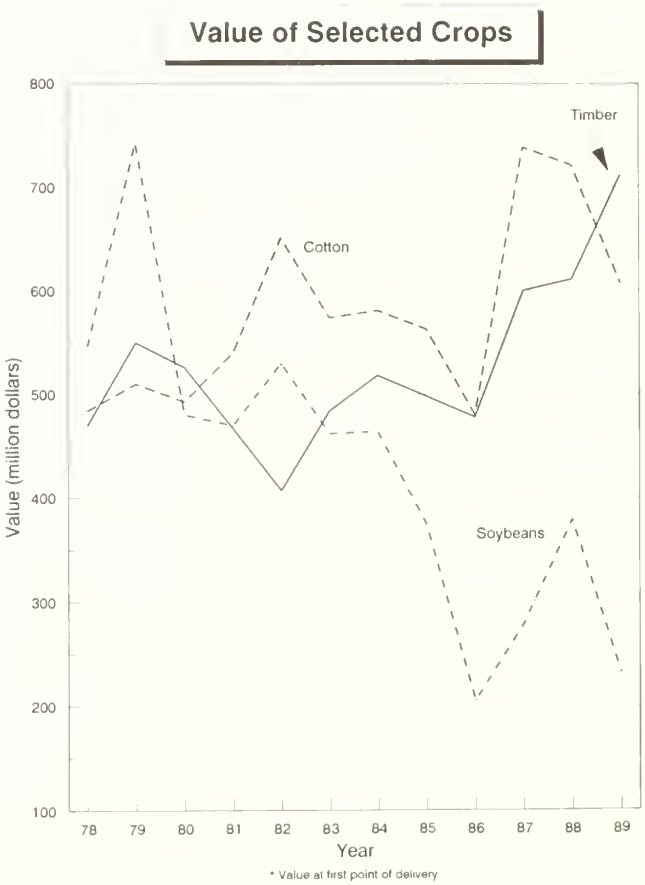


Figure 4. Value of selected crop in Mississippi, 1978-1989. (Sources: Mississippi Cooperative Extension Service—Annual; Mississippi Cooperative Extension Service, 1990.)

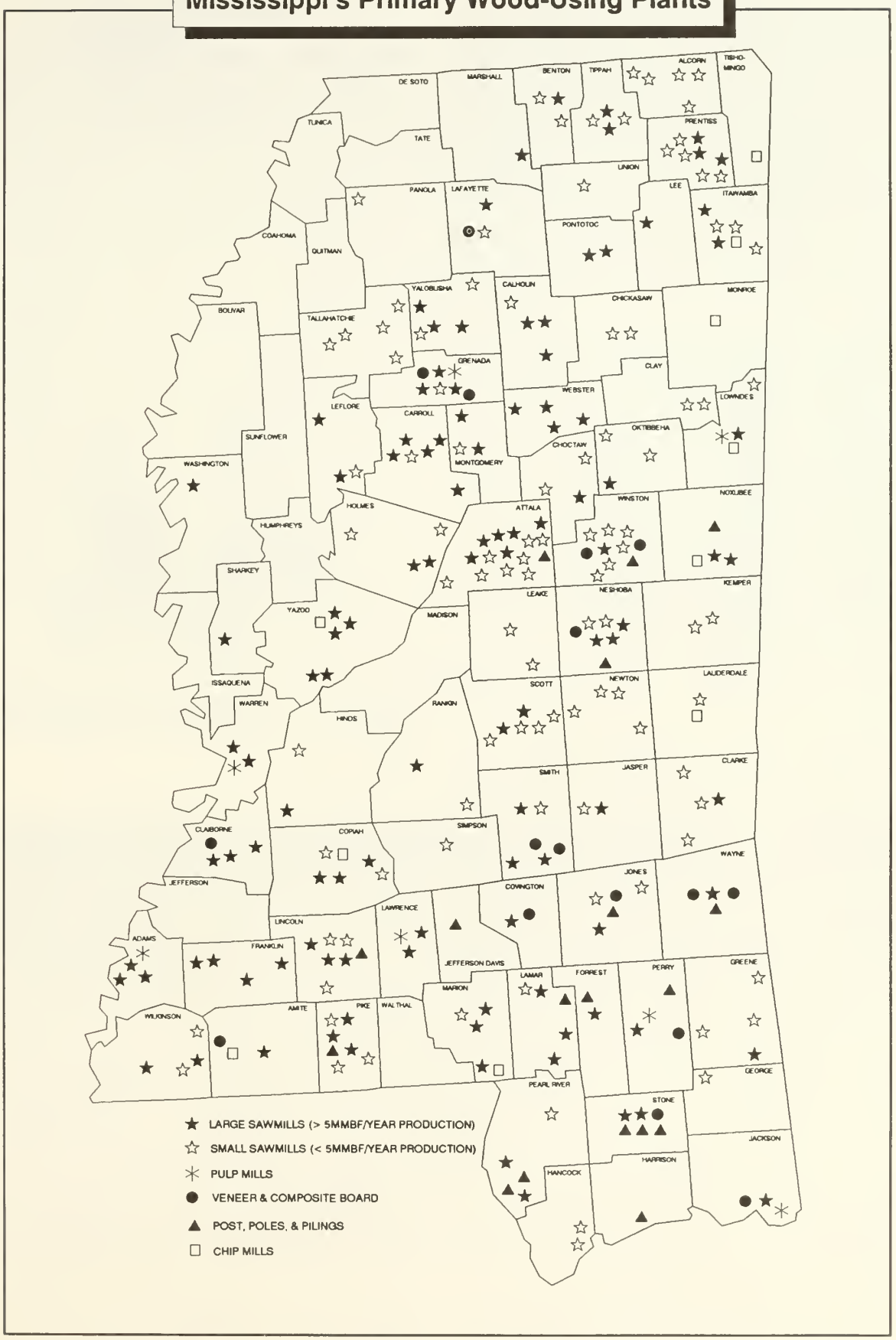


Figure 5. Primary wood-using plants in Mississippi. (Source: Mississippi Forestry Commission, 1990.)

Manufacturing Industries

Utilization of raw materials produced from Mississippi's vast forest resource base is an important component of the state's economy. The forest products industry in Mississippi consists of both primary and secondary manufacturing. Primary manufacturing industries are well distributed throughout Mississippi and encompass those involved in cutting, transporting, and processing raw wood (Figure 5). These industries include logging contractors; sawmills; planing mills; plywood mills; structural panel facilities including veneer, particleboard, waferboard, and oriented strand board mills; pulp mills; chip mills; and posts, poles, and pilings industries.

Secondary manufacturing industries include those involved in the remanufacture of lumber, plywood, veneer, pulp, paper, and other wood products into semi-finished or finished products. Secondary industries in Mississippi include the furniture and fixtures industries, paper mills, millwork producers, wood preserving plants, pallet mills, hardwood dimension and flooring plants, and other lumber and wood product conversion facilities. (For additional information on Mississippi's furniture industry see: Steven H. Bullard, Brian A. Doherty, and Paul H. Short, 1988, *The Mississippi Furniture Industry and Its Use of Wood-Based Materials*, Research Report 13, Mississippi Forest Products Utilization Laboratory, Mississippi State, MS, 20 p.)

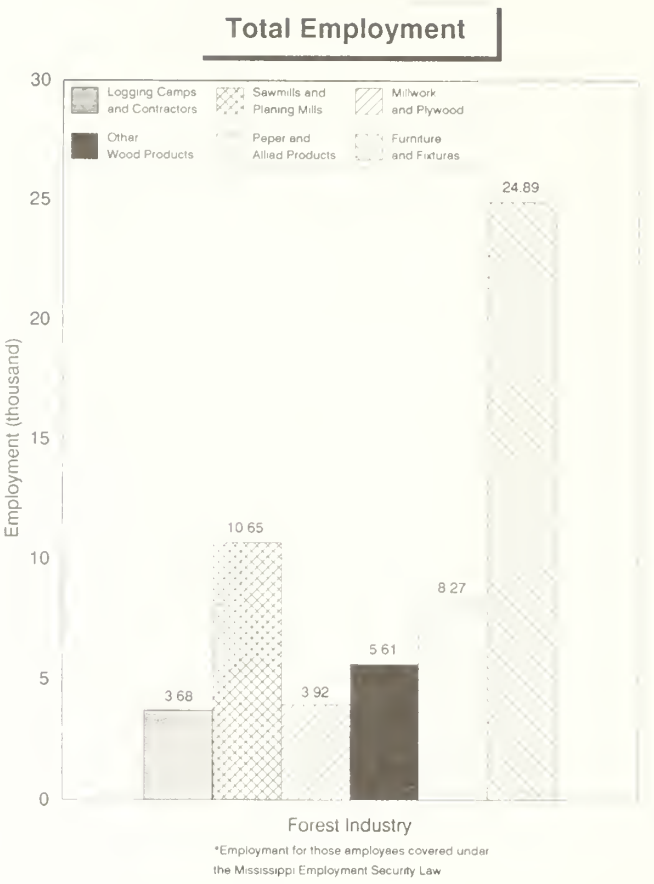


Figure 6a. Total employment by forest industry, Mississippi, 1988. (Source: Mississippi Employment Security Commission, 1989.)

Employment and Earnings

In 1988, approximately 57,000 Mississippians were employed by forest manufacturing industries (Figure 6a). Almost one in every four manufacturing jobs in the state is attributed to the forest industry. Within the industry, the furniture and fixtures sector accounts for 44 percent of total employment. Sawmills and planing mills, and paper and allied products account for 19 and 14 percent of the industry's employment, respectively. The remaining 23 percent of employment is in the logging contractors, millwork and plywood, and other wood product sectors of the industry.

In 1988, forest industry provided over $1 billion in wages for its employees (Figure 6b). Wages earned by forest industry employees accounted for almost 24 percent of all wages earned by all manufacturing employees in the state. Paper and allied products' employees received 23 percent of the total annual wages paid to all forest industry employees, although they represent only 14 percent of all forest industry employees. Furniture and fixtures, and sawmills and planing mills industry employees received 39 and 17 percent of total annual wages, respectively. The remaining 21 percent of total annual wages were paid to remaining forest industry employees.

Forest industry employees earned an average annual wage of $18,208 in 1988, compared to $18,341 for all manufacturing employees (Figure 6b). Paperworkers' annual average wage of $29,402 was 161 percent of the forest industry average and was the highest of all forest industries. Sawmills and planing mills, and furniture and fixtures employees' annual average wages were 91 and 89 percent of the forest industry average, respectively.

Value Added and Value of Shipments

Value added by manufacturing is the difference between the value of shipments and the cost of materials, parts, and services purchased in production. Value added represents the income available for workers and business owners. It is considered the best measure available for comparing the relative importance of manufacturing among industries (USDC Bureau of the Census, 1988).

In 1986, value added amounted to $1.8 billion for forest industries in Mississippi (Table 2). This figure represents 21 percent of the value added by all Mississippi manufacturing industries. Of the industry's total value added, lumber and wood products provided 37 percent, paper and allied products 34 percent, and furniture and fixtures 29 percent.

Value added, expressed as a percentage of value of shipments is an indication of the general performance of an industry because it represents the ability of an industry to

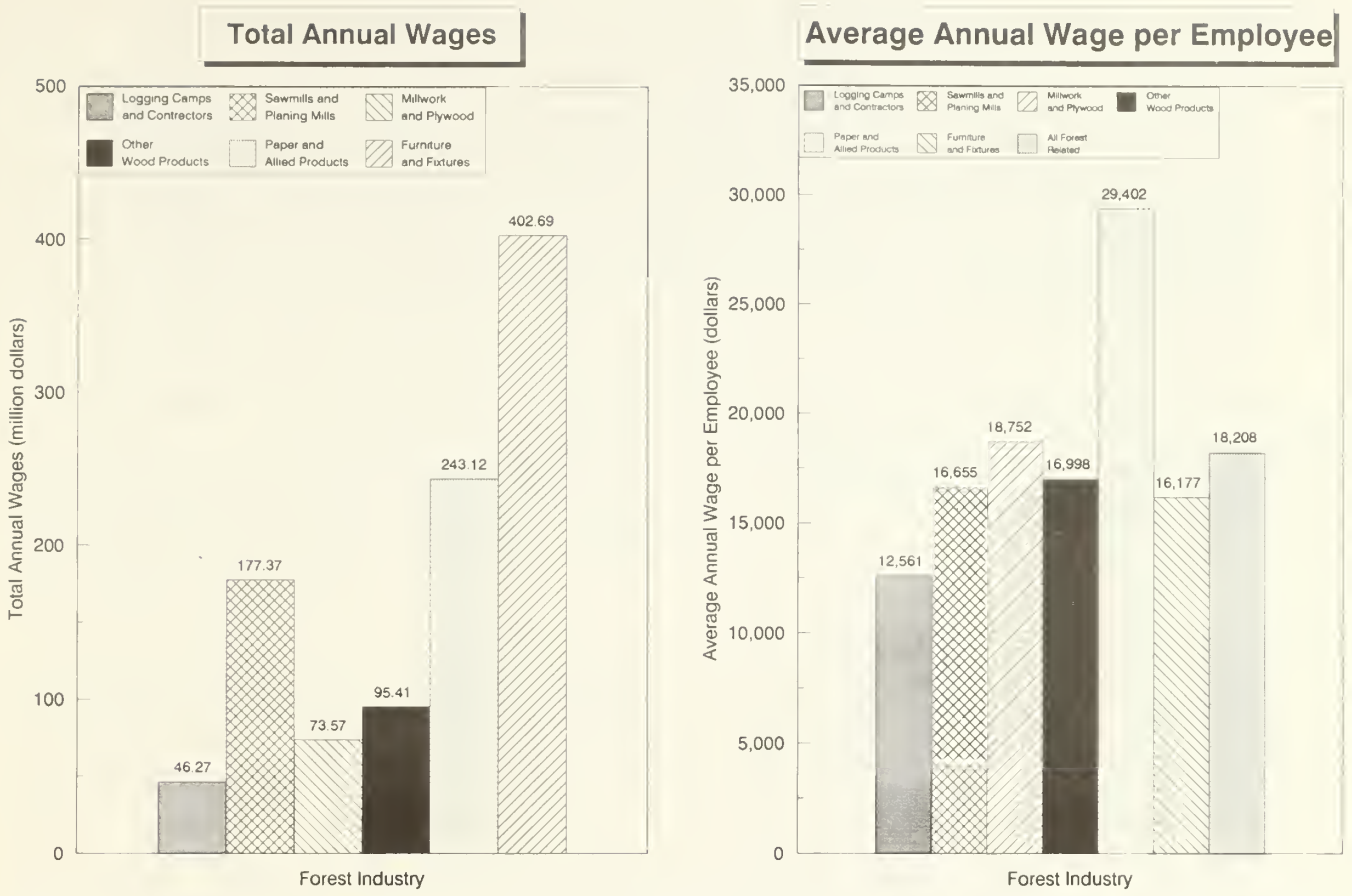
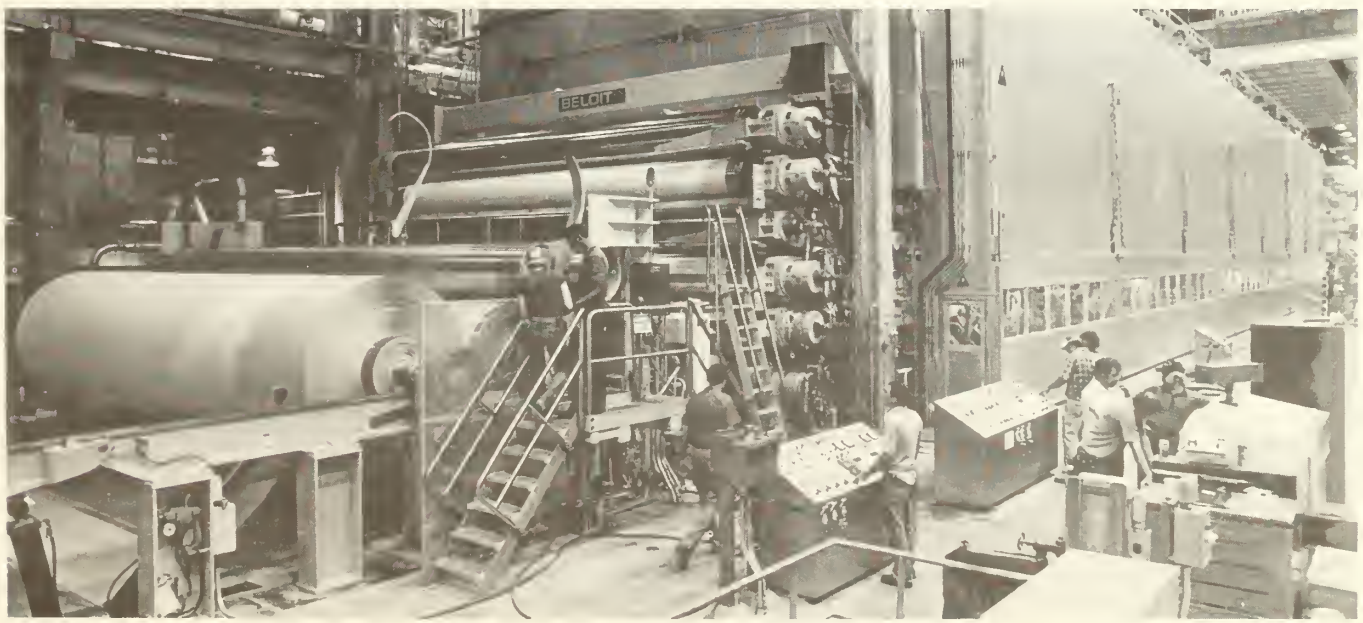


Figure 6b. Total annual wages and average annual wage per employee by forest industry, Mississippi, 1988. (Source: Mississippi Employment Security Commission, 1989.)



Production at the Weyerhauser Paper Company's Columbus, Mississippi lightweight coated papermill contributed to the $1.8 billion in value added by manufacturing for the state's forest industry in 1986. With the opening of the new kraft pulp mill in May 1990, employment at the Weyerhauser complex has grown to 700.

Table 2. Value added, value of shipments, and value added as a percentage of shipments for forest-based industries, Mississippi, 1986.[1]

Industry	SIC code	Value added	Value of shipment	Value added as % of shipment
		($ million)		(percent)
Lumber and Wood Products	24	681.7	1,810.6	37.7
Furniture and Fixtures	25	536.6	1,181.8	45.4
Paper and Allied Products	26	623.3	1,427.5	43.7
All Forest Related Manufacturing		1,841.6	4,419.9	41.7
All Manufacturing		8,973.5	21,719.1	41.3

[1] Source: USDC Bureau of the Census, 1988.

pay wages and profits. Value added as a percentage of value of shipments ranged from 37.7 to 45.4 percent for sectors of the forest industry and averages 41.7 percent (Table 2). All Mississippi manufacturing averaged 41.3 percent.

Forest Products Exports

Exports of forest products are an important component of Mississippi's forest economy. The Mississippi River system and the Tennessee-Tombigbee Waterway facilitate the movement of Mississippi's forest products to deep-water ports in New Orleans and Mobile. Forest products are also exported through Mississippi's ports at Pascagoula and Gulfport.

Wood pulp is the major forest product exported from Pascagoula, while linerboard is the major forest product exported from Gulfport. Wood pulp, lumber, and veneer dominate forest product exports from Mobile. Wood pulp, paper, paperboard, and lumber are the major forest products exported from New Orleans. Additionally, hardwood chips from northeast Mississippi, transported down the Tennessee-Tombigbee Waterway for export from Mobile, have increased substantially within the last 2 years.

In 1986, $565 million worth of forest products, or almost 13 percent of the total value of forest product shipments, were exported (Table 3). The value of forest product exports almost doubled between 1983 and 1986. Paper and allied products accounted for 70 percent of all exports of Mississippi's forest industry in 1986. Furthermore, almost 28 percent of all paper and allied products shipments were exported in 1986.

In 1983, 2,600 Mississippi forest industry employees were involved in the manufacturing of forest product exports (Table 3). By 1986, this figure had increased to 3,300 and represented 7.6 percent of forest industry manufacturing employment. During the same period, export-related employment in the lumber and wood products sector remained at around 1,300, while employment in the paper and allied products sector rose from 900 to 1,600. In 1986, export-related employment in the paper and allied product sector represented 21 percent of its total work force.

Table 3. Shipments and employment related to forest industry exports, Mississippi, 1983-1986.[1]

Forest industry	SIC code	Year	Shipments		Employment	
			Export related	Export as percent of total	Export related	Export as percent of total
			($ mil.)	(%)	(thousand)	(%)
Lumber and Wood Products	24	1983	112.2	6.9	1.4	6.6
		1984	113.1	6.4	1.2	5.6
		1985	114.6	6.7	1.2	5.8
		1986	142.9	7.9	1.4	6.8
Furniture and Fixtures	25	1983	16.8	1.9	0.3	2.1
		1984	18.4	1.9	0.3	2.0
		1985	21.0	2.0	0.2	1.2
		1986	26.5	2.2	0.3	1.8
Paper and Allied Products	26	1983	177.5	17.3	0.9	13.6
		1984	216.3	16.9	1.1	15.1
		1985	267.0	20.5	1.5	19.0
		1986	395.6	27.7	1.6	21.0
All Forest Industry		1983	306.5	8.7	2.6	6.1
		1984	347.8	8.6	2.6	5.9
		1985	402.6	9.9	2.9	6.4
		1986	565.0	12.8	3.3	7.6

[1] Sources: USDC Bureau of the Census, 1987; and USDC Bureau of the Census, 1989.

Mississippi's Pulp and Paper Industry

A common perception is that historically, much of Mississippi's pulpwood has been exported to neighboring states for conversion to wood pulp and subsequent conversion to paper products. Through the years, several forest products firms have located pulp mills in adjacent states close to Mississippi's borders. These mills have drawn pulpwood from Mississippi for the manufacture of wood pulp and paper products. Consequently, Mississippi's neighbors have reaped economic benefits associated with additional output, income, and employment generated in their economy.

In 1988, Mississippi's total pulpwood production (roundwood and wood chips harvested from the state's forests, and wood chips from mill residues, less energy chips) exceeded consumption by 3.1 million cords. This excess, 43 percent of the state's total production, represents the net amount of pulpwood exported to neighboring states for the manufacture of wood pulp and further paper processing. Furthermore, the 3.1 million cords of exported pulpwood are equivalent to 76 percent of Mississippi's pulpwood consumption for the manufacture of wood pulp.

If some out-of-state pulp mills had been located in Mississippi, additional output, income, and employment in the pulp and paper industry and their related secondary industries would have resulted. Assuming that effects on output, income, and employment in the paper and allied industry sector of the state's economy would be directly proportional to increased pulpwood consumption, the foregone opportunities on Mississippi's total economy can be evaluated using Type II output, income, and employment multipliers.

If indeed Mississippi had captured 3.1 million cords of exported pulpwood in 1988, total annual output from Mississippi's economy would have increased by $2.1 billion, while annual incomes would have increased by $361 million, and annual employment would have increased by 16,346 (Table 4). Furthermore, the $361 million of additional personal income would have generated sufficient economic activity to result in an additional $43.4 million of state government revenues in 1988. (State government revenue generated is based on analysis provided by Dr. Daniel K. Lee, Director, Department of Economics, Mississippi Institutions of Higher Learning, Jackson, Mississippi.).

Table 4. Effects on Mississippi's economy of capturing excess pulpwood production.

	Year of data	Units	Paper and allied products		Type II multiplier	Total increases in Mississippi's economy[1]
			Actual	Potential		
Output	1986	($ mil.)	1,427.5	2,508.6	1.98	2,140.6
Income	1988	($ mil.)	243.1	427.2	1.96	360.8
Employment	1988	(No.)	8,269	14,532	2.61	16,346

[1] Values were derived by taking the differences between potential and actual output, income, and employment values and multiplying the differences by the appropriate Type II multiplier.

Forestry and the Mississippi Economy

When growth occurs in one of Mississippi's industries, many other industries are affected. For example, when consumers purchase more wood furniture, the furniture industry must purchase more lumber, adhesives, and other materials used in furniture production. These purchases are termed *direct effects* of the increased consumption. All industries that support the wood furniture industry must then produce more, and must increase purchases from their suppliers. For example, sawmills must purchase more logs to produce more lumber. These purchases are termed *indirect effects* of the consumption. This process continues throughout the economy to the point where many industries have increased production as the result of consumers' furniture purchases. Increased production implies more income and employment for the region's total economy. The effects of expansion or contraction of an individual industry on an economy can be evaluated by the use of an input-output model.

Economic Multipliers

Output, income, and employment multipliers derived from input-output models are used to estimate effects of changes in output, income, and employment. An industry's multipliers are directly related to the proportion of its purchases that are made within the state. The more an industry purchases from in-state suppliers, the larger will be its multipliers (Flick and Teeter, 1988). Type I and Type II multipliers are computed from input-output models. Type I multipliers reflect only the direct effects of changes in economic activity. Type II multipliers reflect direct, indirect, and induced effects of a change in economic activity. Induced effects result from additional household income leading to increased consumer spending in the economy.

Table 5 provides Type I and Type II multipliers for various industries in Mississippi's economy. Table 5 was adapted from a 92-industry input-output model developed by Lee (1986). Although it is the most current model available, it is admittedly dated since it is based on Mississippi's 1977 economy. Therefore, interpretation of results should be viewed with caution. A new input-output model for the state's economy is currently under construction and when completed, can be used to corroborate the conclusions presented here.

The discussion that follows is limited to Type II multipliers because they more fully reflect impacts of changing economic

Table 5. Output, income, and employment multipliers, Mississippi, 1977.[1]

	Type I				Type II		
Sector	Output	Income	Employment		Output	Income	Employment
1 Livestock	1.70	1.49	1.43		2.61	1.88	1.78
2 Other agriculture	1.55	1.32	1.21		2.45	1.67	1.57
3 Mining	1.27	1.37	1.53		1.59	1.71	2.14
4 Construction	1.62	1.42	1.38		2.23	1.78	1.79
5 Food and kindred	1.76	2.90	2.95	MANUFACTURING	2.75	3.65	3.75
6 Textiles	1.37	1.46	1.51		1.75	1.84	2.00
7 Apparel	1.46	1.33	1.26		2.10	1.67	1.54
8 Logging camps	1.43	2.19	2.49	Forest Industry	1.86	2.75	3.21
9 Sawmills	1.55	1.49	1.46		2.10	1.87	1.88
10 Millwork and plywood	1.78	1.83	2.04		2.35	2.31	2.73
11 Other wood products	1.44	1.46	1.43		1.89	1.84	1.83
12 Furniture and fixtures	1.57	1.37	1.37		2.27	1.73	1.79
13 Paper and allied	1.53	1.57	1.84		1.98	1.96	2.61
14 Chemical and allied	1.38	1.66	1.84		1.59	2.07	2.57
15 Rubber and plastics	1.34	1.33	1.32		1.67	1.68	1.77
16 Primary metals	1.47	1.86	1.87		1.73	2.34	2.50
17 Fabricated metals	1.41	1.51	1.60		1.78	1.90	2.15
18 Machinery and electric	1.38	1.34	1.38		1.68	1.67	1.79
19 Transportation equipment	1.41	1.24	1.30		2.10	1.56	1.82
20 Miscellaneous manufacturing	1.50	1.73	1.94		1.84	1.96	2.61
21 Wholesale and retail	1.35	1.25	1.21		2.25	1.58	1.52
22 Services	1.46	1.33	1.28		2.40	1.65	1.61
23 Finance, insurance, and real estate	1.40	1.36	1.39		2.35	1.71	1.85
24 Transportation	1.48	1.32	1.35		2.34	1.66	1.84
25 Communications and utilities	1.41	1.45	1.54		1.99	1.83	2.17
Forest industries average	1.53	1.58	1.68		2.06	1.98	2.23
Other manufacturing average	1.48	1.73	1.82		1.95	2.12	2.41
All economy average	1.48	1.56	1.62		2.08	1.94	2.13

[1] Source: Adapted from Lee, 1986.

activity. Output multipliers relate demand to output. For example, if demand for paper increases by $1.00, the output for the economy will increase by more than $1.00. Mississippi's paper and allied industry has a Type II output multiplier of 1.98 (Table 5). Thus, a $1.00 increase in output for Mississippi's paper industry will stimulate an additional $0.98 of production and sales in other industries.

Income multipliers show changes in household income that occur throughout the economy per unit income change in any industry. Mississippi's paper and allied industries have a Type II income multiplier of 1.96 (Table 5). This indicates that a $0.96 increase in household income will occur in the total state economy when paper industry incomes increase by $1.00.

Employment multipliers indicate changes in employment in the economy per unit employment change in a specific industry. For example, Mississippi's paper and allied industries have a Type II employment multiplier of 2.61 (Table 5). This indicates that 1.61 jobs will be created in other industries of the economy for each job created in the paper industry.

Combined Weighted Type II Multiplier

Type II multipliers for manufacturing industries were weighted and combined to provide a composite multiplier in order to evaluate an industry's relative importance to the state's economy. Weighting was based on each manufacturing industry's relative contribution to output, income, and employment in Mississippi's economy. Weights were then applied to each Type II multiplier. The three weighted Type II multipliers for each manufacturing industry were then summed to provide a combined weighted Type II multiplier.

Combined weighted Type II multipliers ranged from .07 for the textile industry to 1.41 for the forest industry (Table 6). Forest industry's combined weighted Type II multiplier of 1.41 placed it first in importance of all manufacturing industries in Mississippi.

In summary, the economic multipliers for Mississippi's forest industry indicate a strong relationship to the state's economy. This strength of this relationship is based on forest industry's close ties to other industries and to Mississippi's substantial forest resource base.

Table 6. Ranking of combined weighted output, income, and employment Type II multipliers for manufacturing industries, Mississippi.[1]

Industry	Combined Weighted Multiplier[2]
Forest industries	1.41
Food and kindred	1.29
Machinery and electric	0.81
Apparel	0.68
Transportation equipment	0.61
Miscellaneous manufacturing	0.47
Fabricated metals	0.33
Chemical and allied	0.33
Rubber and plastics	0.21
Primary metals	0.15
Textiles	0.07

[1] Sources: Data derived from Lee, 1986; Mississippi Employment Security Commission, 1988; USDC Bureau of the Census, 1985; and USDL Bureau of Labor Statistics, 1988.

[2] Each industry Type II multiplier (output, income, and employment) was weighted by the industry's relative contribution to total value of shipments (1982), income (1987), and employment (1987) for each manufacturing industry. All weighted multipliers for each manufacturing industry were summed to yield a combined weighted multiplier for each industry.

Barge Forest Products Company's new sawmill in Macon, MS, began operation in September 1990, adding 59 people to Mississippi's forest industry payroll. As a result of the new sawmill, an additional 52 jobs were created in the state's economy, according to Type II employment multipliers for sawmills.

Mississippi's Forest Resources

The land area within Mississippi's current state boundaries was heavily timbered when settlers first arrived. Portions of the Black Prairie in northeastern Mississippi and the Jackson Prairie in east-central Mississippi were the only significant nonforested lands. The cotton boom, which started around 1800, greatly increased the rate of settlement and land clearing. By 1860, more than 5 million acres of forest land had been cleared for cultivation and pasture (James, 1951). Clearing of forest land for agricultural uses continued into the 1900's as the state's population and settlement continued to expand. In recent history, Mississippi's total forest land area has remained fairly stable. Considerable changes have occurred within specific regions of the state, however.

Much of the information on Mississippi's forest resources comes from periodic forest surveys conducted at 10-year intervals by the USDA Forest Service. This information is classified by geographic units called "forest survey regions".[2] Figure 7 outlines the forest survey regions of Mississippi. (For additional information concerning Mississippi's forest resources see J. F. Kelly and Mike Sims, 1989, *Forest Resources of Mississippi,* Resource Bulletin SO-147, USDA Forest Service, New Orleans, LA 63 p.)

Pine and oak-pine plantations account for 2.3 million acres of Mississippi's timberlands; almost two-thirds of the plantations are less than 20 years old.

Timberland Area

Since 1957, commercial timberland acreage has remained relatively stable at 55 to 57 percent of Mississippi's total land area, although changes have occurred from region to region (Figure 8). By 1973, for example, timberland in the Delta region had decreased to 1,307,000 acres due to land clearing for soybeans in the 1960's and early 1970's (Porterfield et al., 1978). However, by 1977, an equivalent amount of land had been reclaimed by trees in the Delta region. Furthermore, the Conservation Reserve Program (CRP) of the Food and Security Act of 1985 has added acreage to the state's timberland base. Through 1989, 424,905 acres of Mississippi's highly erodible agricultural lands have been planted or established in trees (USDA Agricultural Stabilization and Conservation Service 1990).

Timberland Ownership

Mississippi's timberlands today are a vast resource covering 17 million acres—56 percent of the state's total area. Ownership of timberland is grouped into four forest land ownership classifications: (1) National Forests, (2) other public, (3) forest industry (including lands leased to forest industry), and (4) nonindustrial private forests (NIPF). Almost 70 percent of Mississippi's timberlands are in NIPF ownerships (owned by farmers,individuals, and small corporations). Another 20 percent are owned or leased by the forest industry. National Forests account for 7 percent of the state's timberland area, and the remaining 3 percent is in other public ownerships (Figure 9, page 17). Other public ownerships include miscellaneous federal, state, county, and municipal timberlands.

Forest Types

Timberlands in Mississippi can be classified into various forest types based on the most common or combination of tree species found in a stand of timber. Stands can be further classified by stand origination — natural or planted. Most

[2] Data presented in this section are from estimates based on periodic surveys, and therefore may be affected by estimating and sampling errors.

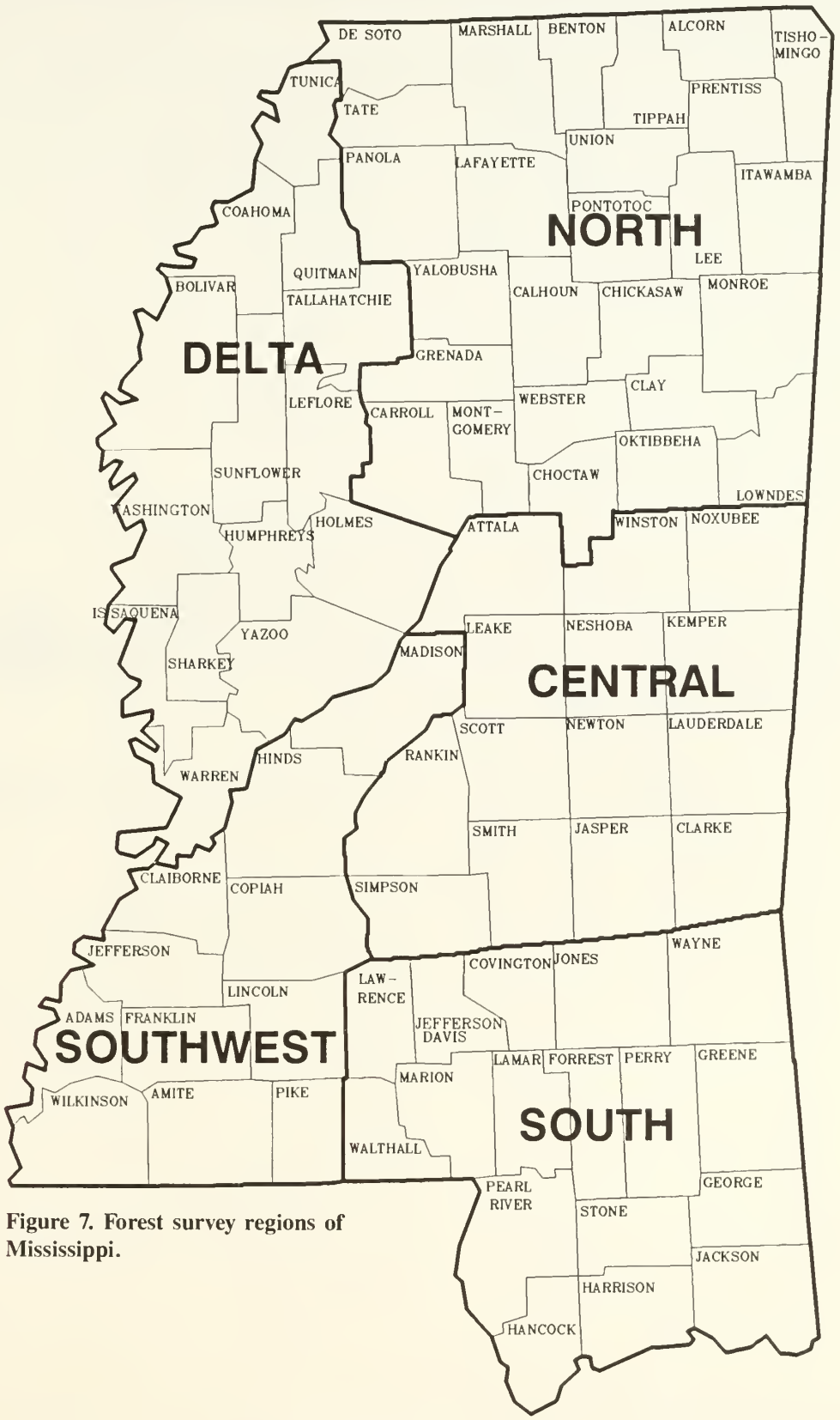


Figure 7. Forest survey regions of Mississippi.

Timberland Area

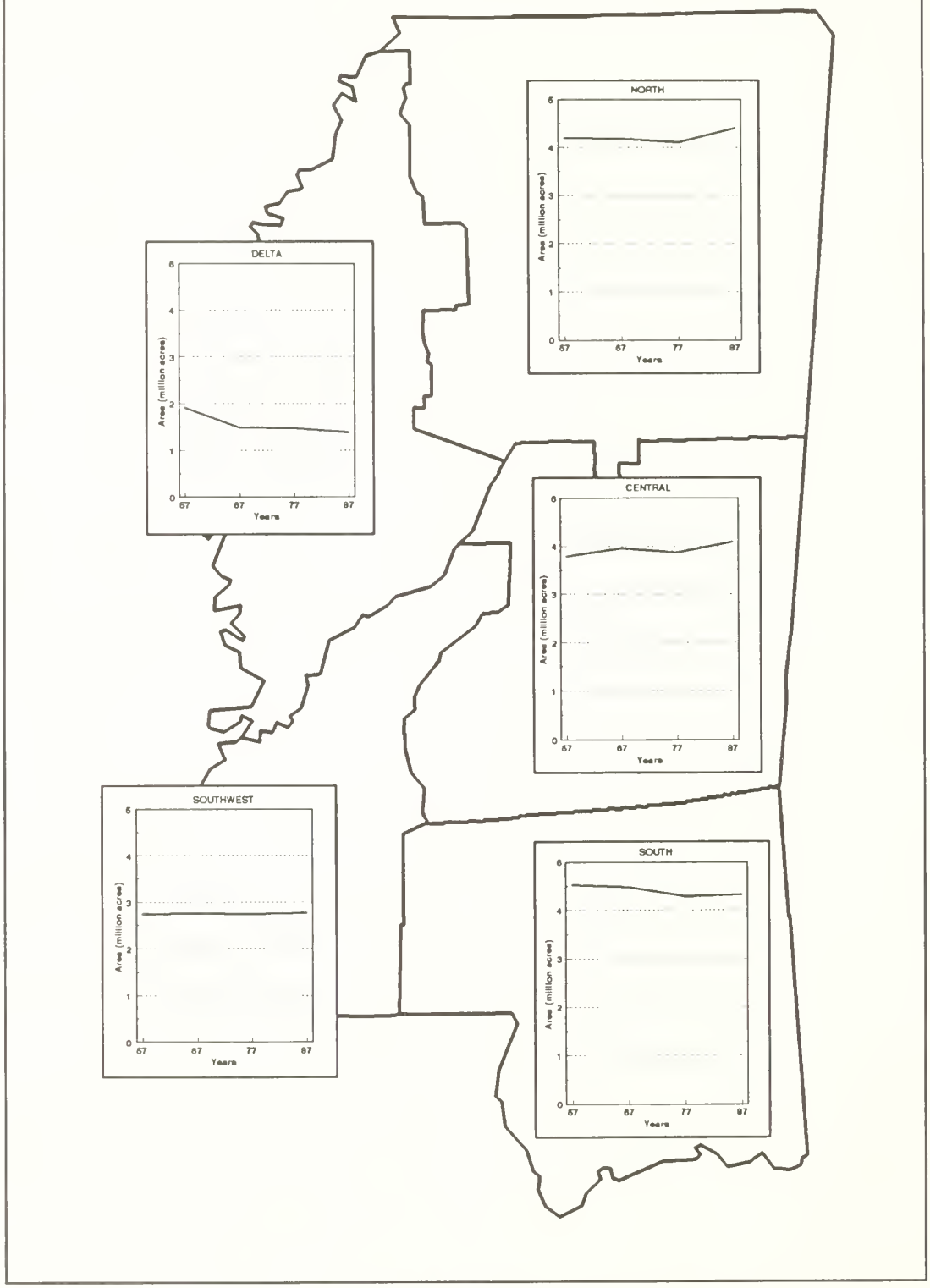


Figure 8. Timberland area by survey region in Mississippi for 1957, 1967, 1977, and 1987. (Source: Kelly and Sims, 1989.)

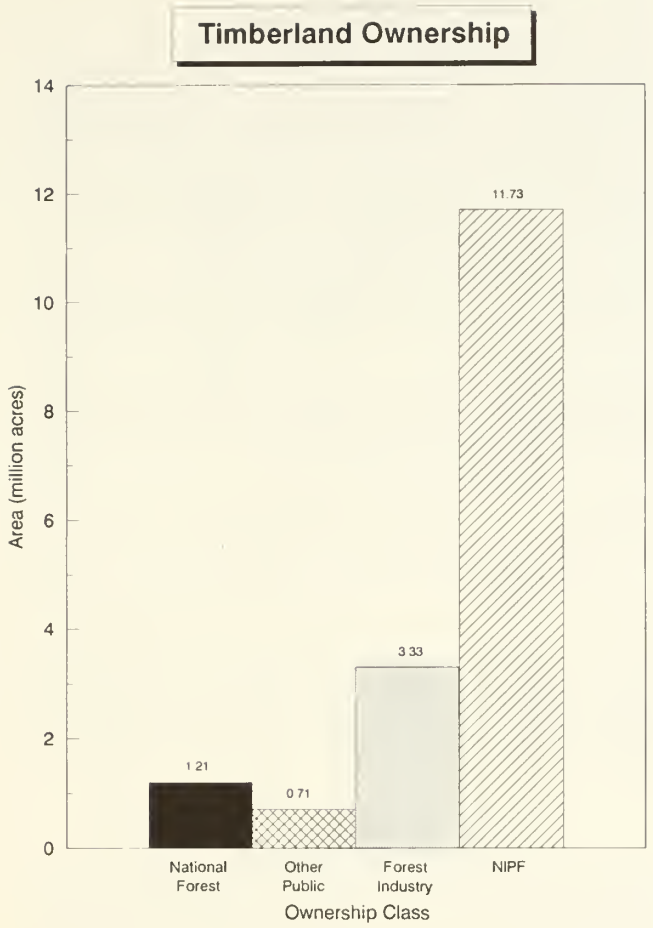


Figure 9. Mississippi's timberland area by ownership class, 1987. (Source: adapted from Donner and Hines, 1987.)

plantations in the state have been planted with pine, and thus are classed as pine or oak-pine forest types. Oak-pine plantations result from the system of classifying forest types. Many young plantations contain sufficient numbers of hardwood stems to be classified as oak-pine, however, many of these stands will evolve into pine type plantations as they mature.

Some forest types are more common on certain ownership classes (Figure 10). For example, forest industry owns or controls 29 percent of the state's pine forest type acreage, while accounting for only 20 percent of all timberland ownerships. NIPF ownership account for 69 percent of all timberlands, but only 57 percent of the pine forest type. Additionally, 79 percent of all oak-hickory forest type acreage is in NIPF ownership. National Forests control approximately 10 percent of the pine and oak-pine forest type acreage but account for only 7 percent of all timberland ownerships.

Plantations

Fifty-three percent of Mississippi's pine and oak-pine forest type plantations are in forest industry ownerships, and 39 percent are in NIPF ownerships; only 8 percent are in National Forests and other public ownerships. Furthermore, plantations account for approximately 50 percent of forest industry's pine and oak-pine forest type acreage, while plantations account for less than 20 percent of those forest types in NIPF ownerships.

Fifty-six percent of the pine and oak-pine plantations in forest industry ownerships are less than 10 years old (Figure 11). Additionally, only 3 percent of forest industry plantation acreage is 31 years or older. On NIPF ownerships, 43 percent of the pine and oak-pine plantations are aged 10 years or younger, and 19 percent of the plantations are over 30 years of age.

Manufacturing facilities, including sawmills, pulp mills, and plywood mills, which rely on **pine** raw materials, are a significant component of Mississippi's forest industry. Consequently, these industries manage their timberland holdings to produce pine forest types. Furthermore, forest industry timber management activities, such as pine plantation establishment, generally favor the perpetuation of pine forest types in order to provide future sources of raw materials.

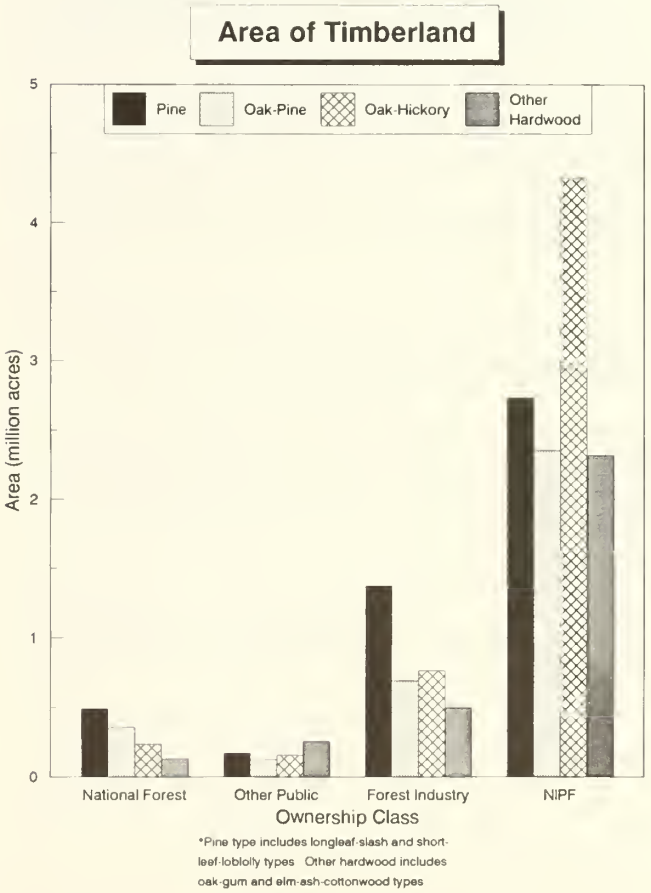


Figure 10. Mississippi's timberland area by ownership class and forest type, 1987. (Source: adapted from Donner and Hines, 1987; and USDA Forest Service, 1989.)

Figure 11. Mississipi's pine and oak-pine type plantation area by ownership class and age class, 1987. (Source: USDA Forest Service, 1989.)

Timberland Productivity

Productivity of timberland is an estimate of the natural capability of the land to grow crops of industrial wood based on fully-stocked natural stands. Productivity is measured in units of cubic feet of wood per acre per year.

The productive potential of fully-stocked natural stands on Mississippi's timberlands averages about 122 cubic feet of wood per acre per year — approximately 1.5 cords (Figure 12). Actual net growth however, is only 56 cubic feet of wood per acre per year, representing only 46 percent of potential net growth. However, Mississippi's average productive potential and actual net growth are comparable to those of neighboring states. With the exception of other public ownerships, actual net growth does not vary substantially between ownership classes (Figure 12).

Considerable proportions of forest industry ownerships are in young stands. This is especially true in pine and oak-pine plantations. As these young stands become established and as they mature, average productivity on forest industry lands should improve as trees grow into merchantable sizes.

Growing Stock Volumes

All live trees of commercial species, excluding rough and rotten cull trees, comprise the growing stock of Mississippi's timberland. Growing stock volume includes the sound wood portion of trees at least 5.0 inches diameter at breast height (d.b.h.) to a top diameter 4.0 inches outside bark (or where the main stem otherwise terminates).

The total volume of softwood growing stock more than doubled from 1957 to 1987 (Figure 13)[3]. However, the rate of increase of softwood growing stock volume has declined every 10 year period since 1957. Mississippi's total volume of hardwood growing stock almost doubled from 1957 to 1987. Furthermore, hardwood growing stock has demonstrated steady increases in volumes, although the rate of increase from 1977 to 1987 declined compared to the previous 10 year period.

Average volumes of softwood and hardwood growing stock are presented by ownership class and forest type in Figure

[3] Minor changes in survey procedures have occurred between 1957 and 1987 that may affect compatibility of data. These changes may limit very detailed analyses between survey intervals, however, general trends and comparisons can be made.

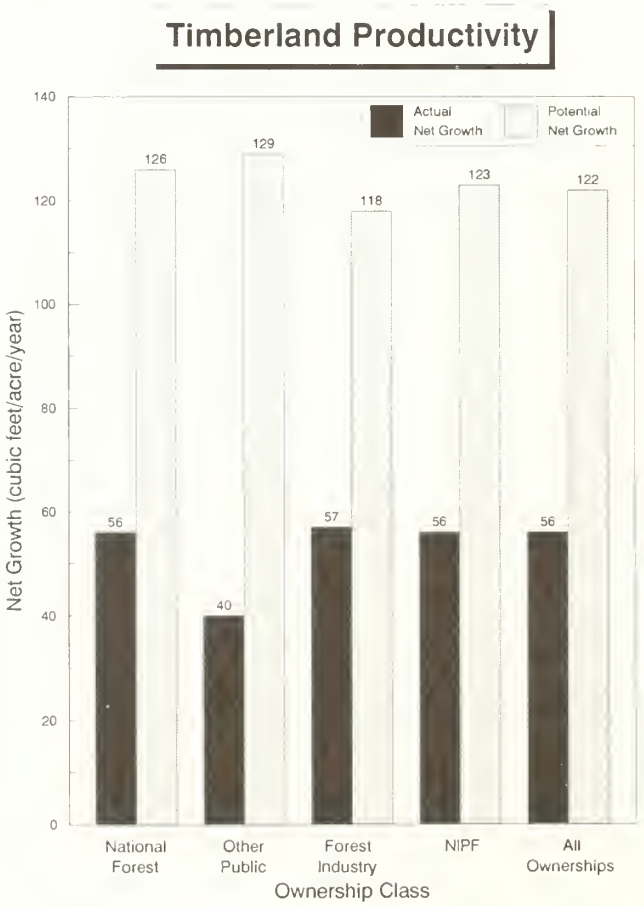


Figure 12. Productivity of Mississippi's timberland by ownership class, 1987. (Source: USDA Forest Service, 1989.)

Figure 13. Growing stock volume of Mississippi's timberland by species group, 1957-87. (Sources: Van Sickle and Van Hooser, 1969; Donner and Hines, 1987; Table 17 (adapted); and USDA Forest Service, 1989a.)

14, page 20. Public ownerships have the highest average volumes per acre of softwood and hardwood growing stock for each of the forest types. The average volumes of softwood and hardwood on forest industry lands are very similar to NIPF averages, but almost without exception, average volumes for the private landowners classes are lower than those of public ownerships. However, average volumes per acre of softwood growing stock on forest industry ownerships should increase as their abundant young plantations mature.

Sawtimber Volumes

Public ownerships have the highest average volumes per acre of softwood and hardwood sawtimber for all forest types (Figure 15, page 21). Forest industry ownerships have greater average volumes per acre of softwood sawtimber than NIPF ownerships for the natural pine and oak-pine forest types. However, NIPF ownerships' pine and oak-pine plantation average volumes per acre of softwood are higher than forest industries' because their plantations are proportionally older. Average volumes per acre of hardwood sawtimber for forest types are generally greater for NIPF ownerships than the forest industry ownership class. Lower volumes per acre of growing stock and sawtimber on forest industry and NIPF ownerships as compared to public ownerships reflect the reliance of forest industries on Mississippi's private timberland resource for raw materials.

Growth and Removals

Net annual growth is the net increase in the volume of trees during a specified year. Net annual growth includes the incremental growth in net volume of trees at the beginning of a specific year, plus the net volume of trees reaching the minimum size class during the year, minus the volume of trees that die and those trees that become rough and rotten. Net annual removals are the net volume of growing stock or sawtimber trees removed from inventory by harvesting, cultural operations, such as timber stand improvement, land clearings, or changes in land use (Murphy, 1978).

The relationship between average net annual growth and average net annual removals (growth-removal ratios) can provide a general indication of under-utilization or over-utilization of a forest resource. Continuation of a growth-removal ratio of less than 1.0 indicates that removals exceed growth, while a ratio greater than 1.0 indicates that growth exceeds removals. These ratios reflect only general utilization of the forest resource and are not a reflection of Mississippi's current timber supply situation. A growth-removal ratio of less than 1.0 indicates an eventual depletion of the forest resource. A growth-removal ratio greater than 1.0 indicates a maturing forest resource in which net growth eventually approaches zero.

Growth and Removals by Forest Survey Region

Growth-removal ratios for growing stock and sawtimber are presented by forest survey region for the 1978-1987 period in Table 7. These ratios represent average net annual growth and removals for the 10-year interval.

Average net annual growth of softwood growing stock and sawtimber approximately equaled average net annual removals from 1978 to 1987 in the central, south and southwest survey regions of Mississippi, while softwood growth exceeded

Table 7. Ratio of average net annual growth to average net annual removals for growing stock and sawtimber by survey region, Mississippi, 1978-1987.[1]

	Growth-Removal Ratio			
	Growing Stock		Sawtimber	
Survey Regions	Softwood	Hardwood	Softwood	Hardwood
Delta	1.25	2.47	1.68	2.39
North	1.11	1.59	1.40	1.97
Central	0.88	1.45	1.12	1.67
South	1.00	1.82	1.08	1.72
Southwest	0.96	2.38	1.17	2.66
All Regions	0.98	1.81	1.18	2.05

[1] Sources: Adapted from Donner and Hines, 1987; and Kelly and Hines, 1987a-e, Tables 23 and 24.

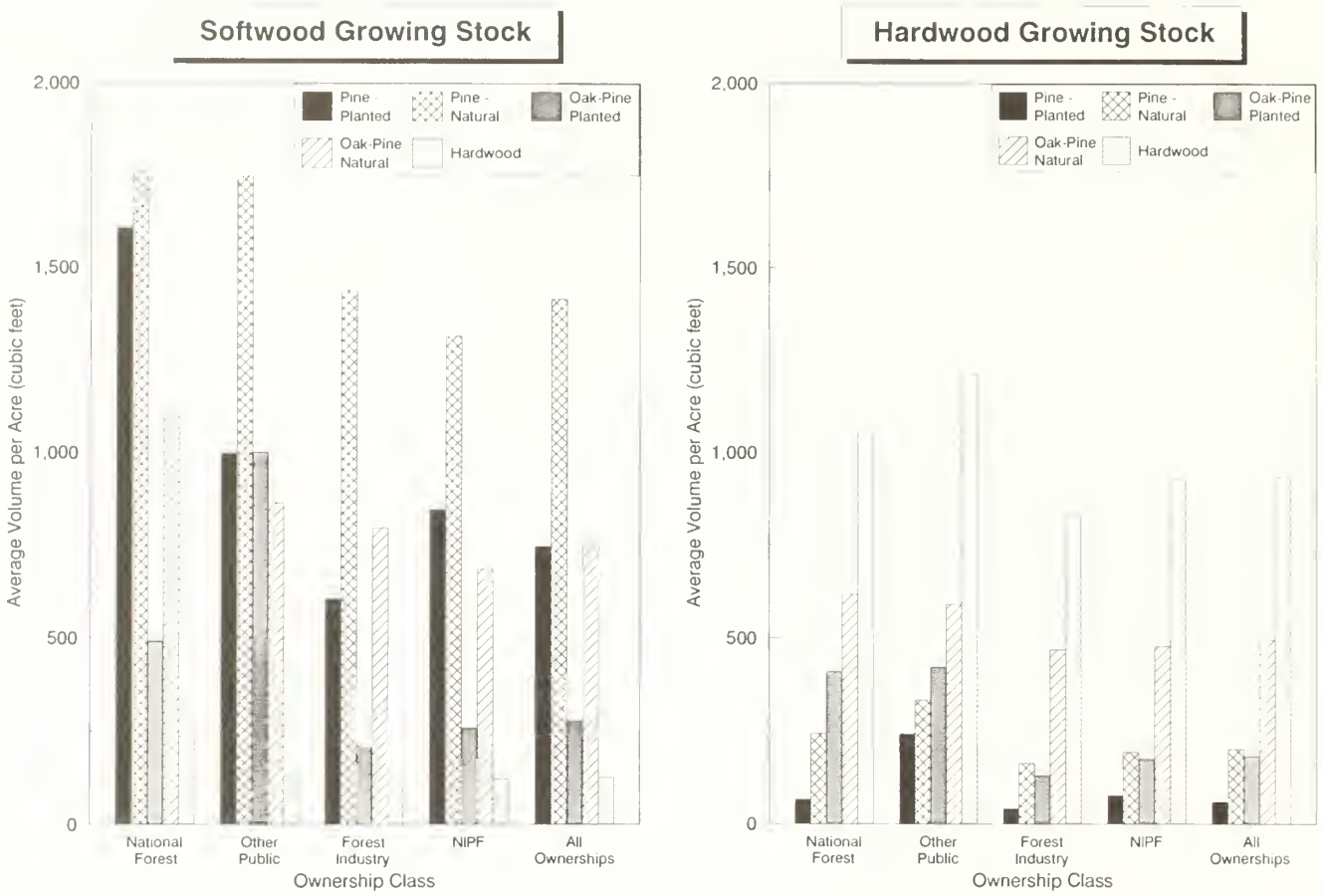


Figure 14. Average volume per acre of softwood and hardwood growing stock by ownership class and forest type, Mississippi, 1987. (Source: USDA Forest Service, 1989.)

removals for the Delta and north survey regions. Greater softwood removals in the southern portion of the state relative to other areas in the state results from a higher concentration of forest industry timberland ownerships and pine-utilizing mills.

Hardwood growth exceeds removals for both growing stock and sawtimber in all survey regions. However, there is concern among industry personnel that growth-removal ratios do not completely reflect Mississippi's hardwood timber situation. In recent years, strong hardwood markets for high-quality hardwood logs have existed. Therefore, while net hardwood growth may be occurring, the overall quality of the hardwood stands may be declining. Indeed, Kelly and Sims (1987) reported that the harvest of high-quality timber, lack of regenerating harvested stands, and maturing timber stands, has resulted in an overall lowering of tree grade from 1978 to 1987.

Growth and Removals by Ownership Class

Growth-removal ratios for growing stock and sawtimber are presented by ownership class for the 1968-1977 and 1978-1987 periods in Table 8. Again, these ratios reflect average net annual growth and removals for the 10-year intervals.

Growth-removal ratios for both softwood growing stock and sawtimber within the all ownership class declined between the 1968-1977 and 1978-1987 time periods. From 1978 to 1987, softwood growing stock and sawtimber growth approximately equaled removals, while growth exceeded removals by approximately 50 percent during the previous 10-year period within this class. All of the ownership classes, except other public, demonstrated similar declines in growth-removal ratios for softwood growing stock and sawtimber from 1978 to 1987.

For hardwood growing stock and sawtimber, from 1978 to 1987 average net annual growth was approximately twice that of removals for the all ownerships class, and was essentially unchanged from the 1968-1977 period. The other public and NIPF ownerships had growth-removal ratios similar to the all ownership class for hardwood growing stock and sawtimber. Hardwood growing stock and sawtimber growth has exceeded removals by a multiple of five during both time periods on National Forest ownerships. Growth-removal ratios

Table 8. Ratios of average net annual growth to average net annual removals for growing stock and sawtimber by ownership class and species group, Mississippi, 1968-77 and 1978-87.[1]

		Growth Removal Ratio			
		Growing Stock		Sawtimber	
Ownership Class	Interval	Softwood	Hardwood	Softwood	Hardwood
	(years)				
National Forest	1978-87	0.86	4.78	0.95	5.45
	1968-77	2.54	5.93	2.72	6.08
Other Public	1978-87	1.93	1.65	2.68	2.27
	1968-77	2.02	1.53	2.34	1.84
Forest Industry	1978-87	0.80	0.92	0.85	0.97
	1968-77	1.27	1.60	1.13	1.63
NIPF	1978-87	1.09	2.12	1.35	2.43
	1968-77	1.57	1.73	1.71	1.78
All Ownerships	1978-87	0.98	1.81	1.18	2.05
	1968-77	1.56	1.78	1.62	1.82

[1] Sources: Adapted from Donner and Hines, 1987, Tables 23 and 24; and USDA Forest Service, 1989.

on forest industry land, meanwhile, have declined for both hardwood growing stock and sawtimber—average annual growth approximately equaled removals during the 1978-1987 period.

Growth and Removals—Summary

The overall forest resource situation for Mississippi between 1978 and 1987 indicates that softwood growth approximates removals, while hardwood growth is approximately twice that of removals. However, removals may exceed growth for certain species in select regions of the state (Table 7). With the introduction of new markets, such as the hardwood chip export market served by northeast Mississippi, certain regions of the state could experience declining growth-removal ratios in the near future. Additionally, growth-removal ratios for softwoods might have been greater for the 1978-1987 period, but timber mortality has more than doubled in the last decade, primarily as a result of southern pine beetle epidemics. NIPF ownerships, with large timberland acreage and growth-to-removal ratios greater than 1.0, contribute markedly to the net annual growth that is occurring.

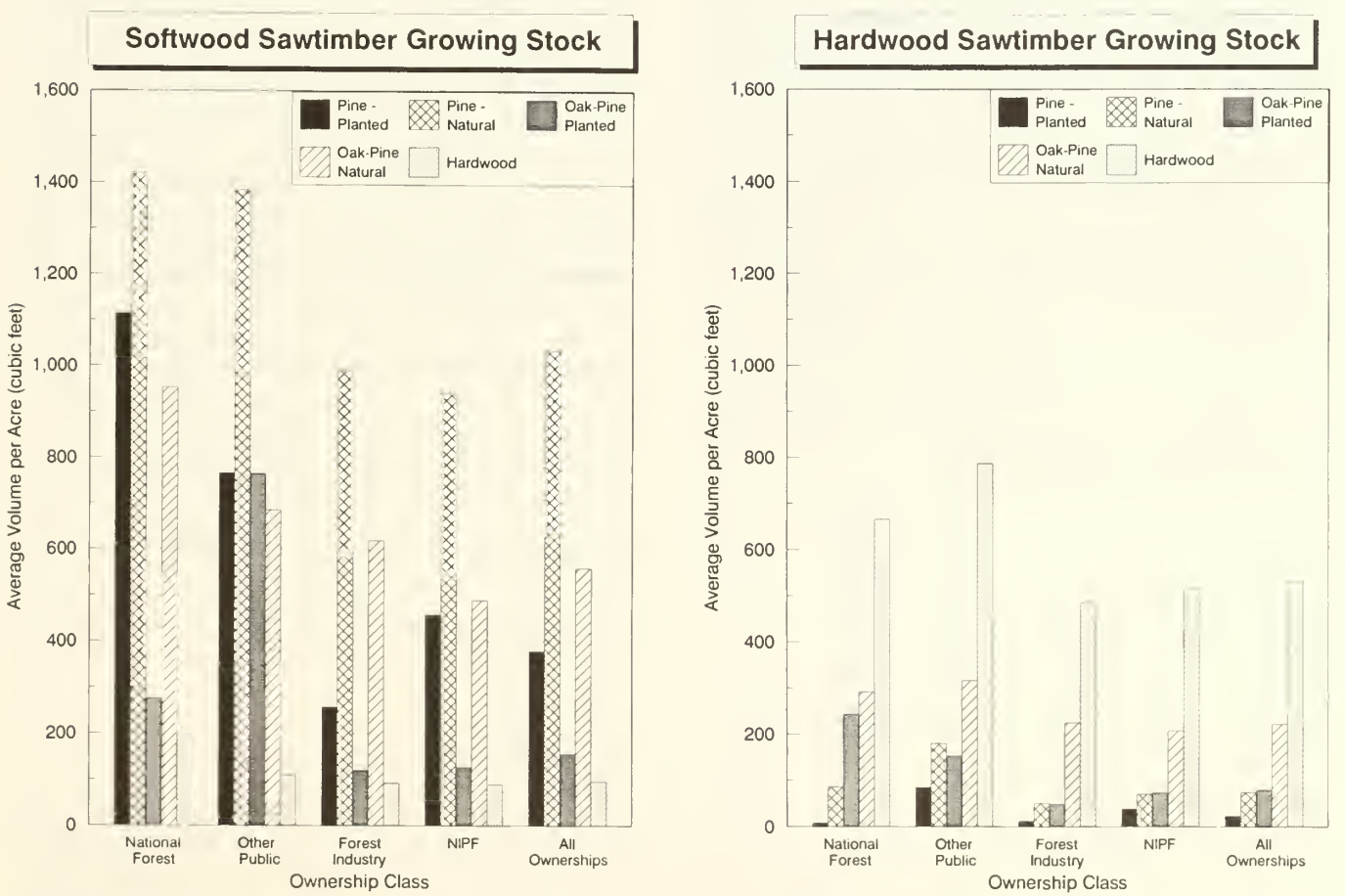


Figure 15. Average volume per acre of softwood and hardwood sawtimber growing stock by ownership class and forest type, Mississippi, 1987. (Source: USDA Forest Service, 1989.)

Nonindustrial Private Forest Landowners

The future of Mississippi's forest resource will be determined largely by the management practiced on the 11.7 million acres of timberland controlled by nonindustrial private forest (NIPF) landowners. NIPF landowners own nearly 70 percent of Mississippi's forest land. Characteristics of these landowners will influence the level of forest management, and thus the yield of forest products, expected on this land. Who owns Mississippi's NIPF lands? What are their timber selling plans? The USDA Forest Service completed a survey of 655 Mississippi NIPF landowners in 1988 (Baird and Doolittle, 1988). Results of this survey, summarized in the tables that follow, are expressed in terms of the number of NIPF acres affected by each response.

Size of Forest Holding and Merchantable Timber

NIPF landowner investments in forestry (level of forest management intensity) are determined by the acreage and volume of merchantable timber owned (Straka, 1985). Several explanations for the positive relationship between timber production on NIPF's and tract size have been proposed (Straka et al., 1984). First, larger tract sizes allow for greater economies of scale. On a per acre basis, larger tracts cost less to manage, so higher expected returns encourage investment in forest management. Second, NIPF landowners who are not primarily interested in timber production (i.e., those interested in recreation, aesthetics, or other benefits), can satisfy their needs from a relatively small acreage. Landowners interested in timber production are more likely to invest in larger acreages. Third, owners of larger tracts tend to have higher incomes and higher net worths than owners of smaller tracts. Thus, owners of larger tracts are more likely to invest in forest management.

Table 9. Timber land tract size and number of tracts owned or managed by Mississippi nonindustrial private forest landowners, by acreage owned, 1988.[1]

Tract Size	Timberland Acreage Owned
(acres)	(percent)
< 10	2
10 - 49	13
50 - 99	14
100 - 499	37
500 - 999	12
1,000 +	22
Number of Tracts Owned By A Single NIPF Landowner	
(No.)	
one	49
two	20
three	10
four +	21

[1] Source: Baird and Doolittle, 1988.

Most of Mississippi's NIPF land belongs to owners who control fairly large acreages; more than 70 percent is held by owners who control 100 acres or more (Table 9). This suggests that Mississippi's NIPF land has a significant advantage for attracting forest management investment. Nearly half of Mississippi's NIPF timberland is held in single tracts (Table 9).

Most NIPF landowners sell timber because the timber is merchantable (responses included "timber was mature," "grow different species," "improve growth," and "salvage timber"). Table 10 suggests that this is the case in Mississippi. Generally, as timber becomes merchantable, the forest landowner realizes he is holding an economic asset and harvests the timber.

Nevertheless, survey responses indicate that only 68 percent of Mississippi's NIPF owners plan to harvest their timber in the future (Table 10). Does this mean that 32 percent of NIPF land in Mississippi will be unavailable for timber harvest? Stone (1970) first addressed this question in Michigan. Most NIPF landowner studies estimate that almost one-third of respondents do not plan to harvest timber. Over time, however, most NIPF land becomes available for timber harvesting. Ownership of tracts changes and owner attitudes towards harvesting change. Over time, economic opportunities tend to persuade reluctant landowners to convert mature timber to cash (Stone, 1970). Carpenter (1985) stated that "while the proportion of owners favoring or opposing timber harvest is reasonably consistent at any particular time, it is not the same timber tracts for which owners hold a particular view. New owners hold different attitudes or the same owners have changed their attitude as their circumstances or percept ions change." Thus, Table 10 does not present trends that are likely to impact the long-run timber supply situation in Mississippi.

The strong positive relationship between "acres of timberland owned" and "plans to sell" timber is amply illustrated in Table 10. The more timberland an NIPF owner controls, the more apt he is to sell timber.

NIPF Landowner Characteristics

Nearly 70 percent of NIPF land in Mississippi is owned by individuals, or individuals and their spouses (Table 11). Partnerships with relatives account for another 13 percent of these lands.

One of the most distinctive characteristics of NIPF landowners is their occupation. Table 11 presents data on this for

Mississippi. Those in the "retired" occupation category own the most acreage. Owners in this category are least likely to sell timber, while the "farmer-rancher" owner is most likely to sell based upon current plans.

Timber selling plans by "major source of income" are comparable to those by "occupational category" (Table 10). Owners who rely primarily upon farming and forestry for income are more likely to sell timber than owners in the other income categories. Pensioners are least likely to sell timber. Owners on salary/wages, in business, or living on interest, reported selling intentions representative of the overall population of owners.

More than half of NIPF land in Mississippi is owned by persons aged 55 or older. Indeed, more than one-third is owned by persons above the "official" retirement age of 65 (Table 11). Conversely, only about 13 percent of NIPF land

Table 10. Reasons affecting decision to sell timber and characteristics of NIPF landowners and NIPF land with future timber selling plans, by acreage owned in Mississippi, 1988.[1]

Most Important Reason To Sell	Timberland acreage owned
	(percent)
Timber was Merchantable	47
Needed Money	21
Good Price	17
To Clear Land	10
Scheduled by Plan/Forester	5
Future Plans to Sell	
Yes	68
No	32
Timberland Owned	**Plans to Sell**
(acres)	(percent of timberland owned)
1 - 9	18
10 - 49	43
50 - 99	60
100 - 499	71
500 - 999	68
1,000 - 4,999	83
5,000 - 9,999	95
10,000 +	97
TOTAL	68
Selling Plans by Major Source of Income	
Salary/Wages	68
Farming	78
Business	69
Pension	56
Interest	68
Timber	88
TOTAL	68
Major Species Composition	
Mostly Pine	78
Mostly Hardwood	63
Half and Half	55
TOTAL	68

[1] Source: Bard and Doolittle, 1988.

Table 11. Characteristics of Mississippi's NIPF landowners, by acreage owned, 1988.[1]

Characteristics	Timberland Acreage Owned
Ownership Category	(percent)
Individual-Spouse	69
Partnership (Relatives)	13
Partnership (Non-Relatives)	1
Undivided Estate	7
Other	10
Occupation	
Farmer-Rancher	12
White Collar-Professional	23
Blue Collar-Technical	22
Retired	43
Age (years)	
<35	3
35-44	10
45-54	22
55-64	27
>65	38
Education (No. years)	
0-8	7
9-11	6
12 (High School Diploma)	30
13-15	15
16 (College Degree)	25
>17	16
No Response	1
Place of Residence	
Farm	33
Rural but not a farm	27
Town (<2500)	7
Town (2,500 - 100,000)	26
City (>100,000)	7
Distance residence from timberland (miles)	
0 (lives on land)	43
1-9	25
10-19	12
20-29	4
30-39	2
40-49	1
50-100	5
>100	8
Primary benefit of owning timberland	
Timber Production/Sales	47
Investment/Future Income	14
Recreation/Hunting	12
Income	11
"Ownership"	4
Firewood	3
Beauty/Land Appreciation	2
Livestock Grazing	2
Home for Wildlife	2
Other	3

[1] Source: Baird and Doolittle, 1988.

belongs to owners younger than 44. It appears that the median age of owners (57 years in Mississippi) is increasing. Although age is not a major factor affecting an owner's timber selling plans, the level of education attained does make a difference. Generally, as the level of education attained by owners increases, the proportion of land on which timber sales are planned also increases. Of the NIPF landowners who responded to the question on education, nearly 40 percent were college graduates (Table 11). The survey found that land owned by a college graduate was nearly twice as likely to support a timber sale as land whose owners have less than a high school education.

Where do Mississippi's NIPF landowners live? Table 11 indicates that most landowners live in rural areas; about one-third live on farms and approximately another one-fourth live in other rural areas. More than two-thirds of these owners live less than 10 miles from their timberland (Table 11). Landowners who live more distant from their timberland are more likely to sell timber.

Of the applicable respondents to the survey, 79 percent were male and 21 percent were female. Ninety-six percent were white and 4 percent were black. Approximately 13 percent of Mississippi's NIPF land is leased to someone else. Of the leased NIPF land, 42 percent is under a hunting lease, 16 percent is under a mineral lease, 15 percent is under a timber lease, 14 percent is under an agricultural lease, 9 percent is under a grazing lease, and 4 percent is under another type of lease.

What is the primary benefit that NIPF owners receive from the timberland they own or manage? The primary benefit is mainly timber production and income (Table 11). More than 70 percent of the land belongs to owners who are primarily interested in income, either currently or in the future. Twelve percent of the land is owned primarily for recreation or hunting. Owners of the land held mainly for timber production and income are much more likely to make future timber sales.

Only about 18 percent of NIPF land in Mississippi is covered by a written management plan. As expected, most (85 percent) of this NIPF land belongs to owners who plan to sell timber in the next 10 years. In contrast, 64 percent of the land belonging to owners with no management plan is not scheduled for a timber sale in the next 10 years.

According to NIPF owners, 47 percent of their land contains "mostly pine," about 24 percent contains "mostly hardwood," and nearly 29 percent is "half-and-half." Interestingly, these estimates of species composition are strikingly different from the 1987 Mississippi forest survey results. The USDA Forest Service (Donner and Hines, 1987) found that only 23 percent of NIPF land is in pine types (longleaf-slash or loblolly-shortleaf), 20 percent is mixed (oak-pine), and 57 percent is hardwood (oak-hickory, oak-gum-cypress, or elm-ash-cottonwood). It appears that owners perceive that their land contains more pine than is actually the case. It is conceivable that a large portion of the "oak-pine" type in the USDA Forest Service survey is perceived as "mostly pine" by owners.

While NIPF landowners may own less pine than they think, the "mostly pine" owners are significantly more likely to plan timber sales (Table 10). In fact, the relative marketability of the major species types are matched by the order of planned selling among owners: "mostly pine," first; "mostly hardwood," second; and "half-and-half" last.

Mississippi Forestry Commission

The Mississippi Forestry Commission (MFC) was established as a state agency in March 1926. Its primary mission was initially to prevent and suppress wildfires and to encourage the reforestation of cut-over and eroding acres on NIPF land. The MFC now provides numerous services to NIPF landowners in Mississippi.

Protection of the state's forests from wildfire is still a major function of the MFC. Other functions include application of modern forest resource management practices to NIPF lands and advocacy of stewardship of forests for a wider range of forest benefits. Practices to enhance aesthetics, to improve wildlife habitat, and to prevent erosion have become major objectives of many NIPF landowners. The services of the MFC include these practices as well as the continuance of a long-term effort to increase overall forest productivity. (The MFC section presented here is based on annual reports and information from the MFC State Forester's Office, Jackson, MS.)

Fire Prevention and Protection

Mississippi Forestry Commission fire prevention and suppression efforts, supported by effective public education programs carried out by the entire public and private forestry community, have succeeded in reducing the area burned annually by wildfires from an estimated 10 million acres in 1926 to approximately 57,000 acres in fiscal year 1989 (FY89). The number of wildfires occurring annually has also declined. Only 3,886 wildfires were suppressed during the FY89 fire season, the lowest number since 1960 (Table 12).

The MFC participates in the Rural Community Fire Protection Program. Since 1975 more than 400 rural volunteer fire departments have received Federal matching funds for firefighting equipment through small federal grants administered by the MFC. A law was enacted in FY89 to increase the tax on timbered and noncultivatable land from 2

Table 12. Forest acres burned and number of forest fires suppressed by the Mississippi Forestry Commission, 1983-1989.[1]

Date	Acres burned	Number of fires
1983-84	86,948	6,781
1984-85	71,248	6,122
1985-86	140,827	9,408
1986-87	60,312	4,562
1987-88	218,777	12,429
1988-89	56,625	3,886

[1] Source: Mississippi Forestry Commission.

Table 13. Record of management assistance provided by the Mississippi Forestry Commission, by service provided, 1986-1989.[1]

Item	1986-87	1987-88	1988-89
Reconnaissance or diagnosis cruise:			
(no. of cases)	15,469	15,036	15,728
Management plans:			
Number	4,267	4,356	3,852
Acres	288,646	249,111	210,564

[1] Source: Mississippi Forestry Commission.

cents ($.02) to 9 cents ($.09) per acre by 1992. These tax revenues are dedicated to the fire control program of the MFC.

Forest Resource Management

The Mississippi Forestry Commission provides limited professional forestry advice and assistance for private forest owners, processors of primary and secondary wood products, and public land agencies. Services include preparing forest management plans, including timber sales, and supplying quality seedlings for reforestation projects (Table 13).

On July 1, 1986, the MFC became responsible for prescribing management and harvesting practices on approximately 380,000 acres of 16th Section school timberlands. The MFC is to bring all 16th Section timberlands to maximum productivity by 1995. Through 1989, the MFC had regenerated more than 28,000 acres of 16th Section timberland and performed release treatments on an additional 6,540 acres. Most timber sales administered by the MFC in FY89 were for 16th Section timberlands, and sales receipts totalled almost $8 million.

Personnel of Mississippi Forestry Commission provide limited professional forestry advice and assistance to Mississippi's nonindustrial forest landowners who control nearly 70 percent of the state's timberland.

Table 14. Numbers of applications, acreage of forest land improved, and funds approved for programs authorized by the Mississippi Forest Resources Development Act (FRDP) and the Forest Incentives Program (FIP), Mississippi, 1987-88 and 1988-89.[1]

		Year	
Item	Program	1987-88	1988-89
Applications (no.)	FRDP	1,027	920
	FIP	256	372
Planted or Seeded (acres)	FRDP	48,333	45,598
	FIP	14,796	20,292
Released or Site			
Prepared for Natural	FRDP	4,840	4,202
Regeneration (acres)	FIP	18	327
Cost Share Approved for	FRDP	2,580,484	3,555,940
Above Work (dollars)	FIP	795,424	1,383,470
Fire Breaks (feet)	FRDP	----------	142,705
Cost Share (dollars)	FRDP	----------	7,792

[1] Source: Mississippi Forestry Commission.

In 1974, Mississippi became the second state to enact a Forest Resource Development Program (FRDP). Funding for the cost-share program is derived from the Timber Severance Tax. Up to 65 percent of the cost of reforestation practices has been paid to qualified landowners through the FRDP. Beginning July 1, 1990, the FRDP cost-share will be 50 percent. In FY89, FRDP provided $3,555,940 for cost-sharing to private landowners and for development of 16th Section school timberlands (Table 14).

The federal Forestry Incentives Program (FIP) has also provided a major impetus to the regeneration of Mississippi's forest lands. Table 14 summarizes FIP and FRDP activity. The Agricultural Conservation Reserve Program was used by a small number of landowners to improve 8,199 acres of forested acreage in 1989. Furthermore, the CRP has supported the conversion of 424,905 acres of Mississippi's highly erodible and eroding croplands to forest plantations through 1989.

The MFC performs firelane construction and prescribed burning, with more than 3,900 miles of firelanes built or

Table 15. Miles of firelanes constructed and acres of prescribed burning by the Mississippi Forestry Commission and number of owners receiving the services, 1983-1989.[1]

	Firelane Construction		Prescribed Burning	
Date	Miles of firelanes	Number of owners	Acres burned	Number of owners
1983-84	2,749	2,405	68,292	1,056
1984-85	2,661	2,183	74,705	1,212
1985-86	2,625	2,197	61,623	1,098
1986-87	2,519	1,993	47,443	640
1987-88	2,589	2,016	63,705	896
1988-89	3,901	1,499	54,100	781

[1] Source: Mississippi Forestry Commission.

refurbished, and 54,100 acres prescribed burned in FY89 (Table 15). Another service is the provision of vendor lists for forestry services such as tree planting, mechanical site preparation, and cull tree removal to private landowners. Surveillance flights to detect insect and disease damage to forests are also conducted annually. MFC foresters provide urban forestry assistance for individual landowners, builders, developers, and city officials, as well. Information and education programs for civic clubs and school programs are available from local MFC offices.

Mississippi's Consulting Foresters

According to the 1990 roster of registered foresters, approximately 105 individuals in Mississippi, with various qualifications and specializations, have the title of consulting or self-employed forester. These foresters provide a wide array of forestry services to Mississippi's timberland owners. While the NIPF landowner may be the typical client of most consulting foresters, many also provide forestry services to industrial and public timberland owners. The Mississippi Forestry Commission refers landowners to private forestry consultants and provides directories of consultants.

The Mississippi Association of Consulting Foresters (MACF), an organization of professional consulting foresters who practice in Mississippi, was established as a chapter of the Association of Consulting Foresters of America (ACF) in 1971. Not all of Mississippi's forestry consultants are members of the MACF. Membership in the MACF is limited to those full-time professional foresters who hold professional forestry degrees, have 5 years of practical forestry experience, complete regular continuing education requirements, and have no association in a timber purchasing or procurement entity wherein a potential conflict of interest may exist. Members of the MACF average 27 years of forestry experience, of which 15 years is as a consultant. Furthermore, MACF members manage approximately 1.5 million acres of Mississippi's timberlands on a full-time basis.

The typical client of most forestry consultants is an NIPF landowner owning fewer than 500 acres of timberland. Timber production through the development and maintainance of a productive and profitable forest is usually the primary goal of a forestry consultant's clientele, though wildlife, recreation, and aesthetics are also important. As professional forestry and the needs of NIPF landowners have grown, there has been increased specialization among forestry consultants. Moreover, a critical value of professional forestry consultants continues to be their ability to adapt forest management programs to fulfill a client's goals and objectives, as well to encourage keeping Mississippi's timberlands a productive entity.

Mississippi's Public Forest Resources

National Forests

The USDA Forest Service administers 1.1 million acres of public land in six national forests in Mississippi; the Bienville, Delta, DeSoto, Holly Springs, Homochitto, and Tombigbee (Figure 16). National forests are managed to provide a sustained flow of natural resources, including outdoor recreation, forage, wood, water, wilderness, wildlife, and fish, in combinations that best meet the needs of society now and in the future. Acquired 50 years ago, these once cutover and eroded lands now produce more commodities than any other national forest in the eastern two-thirds of the nation.

National forests in Mississippi yielded 244 million board feet of timber, valued at almost $21 million, in 1988. Revenues exceeded operating expenses by more than $11 million. Mississippi's national forests include the Southern Region tree nursery, where 30 million seedlings are raised annually for forests in nine southern states. More than 13,000 acres were reforested in Mississippi's national forests in 1988.

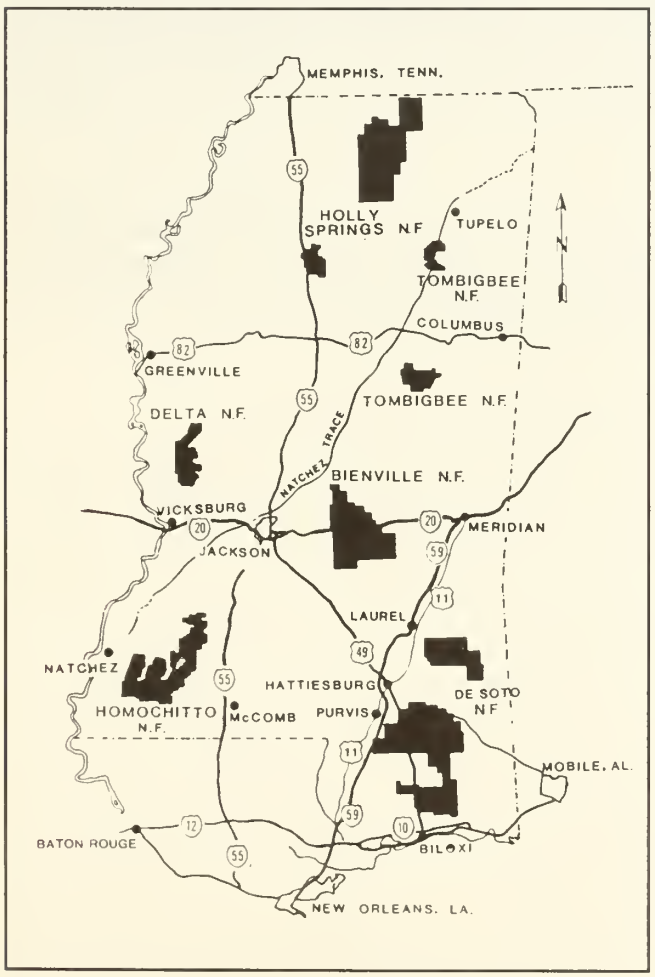


Figure 16. Map shows the locations of the USDA National Forests in Mississippi.

Fire management is used extensively in the management of National Forests. More acres are prescribed burned in the national forests of Mississippi than any other national forest in the nation. In 1988, almost 150,000 acres were treated with prescribed burns to reduce wildfire hazard, improve wildlife habitat, and improve range resources.

More than 1.2 million recreation visitor-days on Mississippi's National Forests were enjoyed by the public in 1988. Recreational activities include hunting, fishing, floating the only segment of a wild and scenic river in the state, hiking, camping in one of two wildernesses or at one of the many developed campsites, picnicking, and swimming. In recent years, recreational use of national forests in Mississippi has been increasing by approximately 6 percent annually.

Economic contributions by Mississippi's national forests are significant. About 2,000 jobs and an estimated $49 million were generated in 1988 for local communities as a result of timber sales from the national forests. In 1988, shared returns amounting to more than $5 million made significant contributions to counties containing national forest land for use in their public schools and for roads.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers has six projects in Mississippi that contain significant forest resources. These projects are divided between two administrative areas, the Vicksburg District and the Mobile District. Arkabutla, Enid, Grenada, and Sardis Lakes, in north-central Mississippi, are part of the Vicksburg District, while Okatibbee Lake, in east-central Mississippi, and the Tennessee-Tombigbee Waterway, in the northeast, are part of the Mobile District.

All five Corps of Engineer lakes have a primary purpose of flood control, although it was realized that land under the Corps' jurisdiction had potential for multiple resource management; i.e. outdoor recreation, wildlife, fisheries, and forest management. Consequently, provisions have been made for multiple use of the natural resources to the maximum extent compatible with the lakes' primary function of flood control. Various public laws guide the Corps in their management.

Forests associated with the five lakes cover approximately 143,000 acres of land. These forests and lakes provide many varied opportunities for outdoor recreation, including sightseeing, fishing, boating, picnicking, camping, swimming, and hunting. More than 12.8 million visitor-days were enjoyed on the lakes and surrounding lands in 1988.

The Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) has the primary responsibility for wildlife

Backpacking in the DeSoto National Forest's Black Creek Wilderness Area is just one of many outdoor activities available to Mississippi's recreationists. Approximately 25 million visitor-days of recreational activities were enjoyed in the state's public forest resources and associated waterways in 1988.

and fisheries management at the lakes. This is supplemented by Corps management activities. Wildlife management activities are aimed at maintaining and improving wildlife habitat and populations.

Forests are managed in a manner that is compatible with and enhances other uses of forest land. Management activities include prescribed burning and fire lane construction to reduce wildfire hazard and to improve wildlife habitat. Timber harvesting activities are undertaken in order to keep stands of trees growing vigorously, reducing the chances of disease and insect attacks. Reforestation efforts include the planting of 500,000 bald cypress and 300,000 pine seedlings annually.

The 234-mile Tennessee-Tombigbee Waterway officially opened in 1985. It joins the Tennessee River near the Mississippi-Alabama-Tennessee border with the Black Warrior Waterway located in Alabama. Approximately 140 miles of the Waterway are located in Mississippi. Providing navigation for commerce, recreational opportunities, and wildlife management are the principal goals and objectives of the Waterway.

Approximately 59,000 acres of forest land and 32,000 acres of water associated with the Waterway are located in eastern Mississippi. Forest management objectives are targeted at maximizing wildlife and recreational values and opportunities. Recreational activities center around public recreational facilities that have been established to include hunting, fishing, camping, water skiing, and swimming. Additional recreation facilities are incorporated in future development plans. In 1988, approximately 6.1 million visitor-days of recreation were reported on the Waterway.

USDI Fish and Wildlife Service

The USDI Fish and Wildlife Service manages seven national wildlife refuges in Mississippi. The primary objective of a national wildlife refuge is to provide habitat for the conservation and protection of all species of wildlife. Specific management objectives for individual refuges depend on enabling legislation for the establishment of the refuge.

The Mississippi Sand Hill Crane National Wildlife Refuge comprises approximately 17,000 acres in the coastal region of southeastern Mississippi. Restoration and protection of crane habitat is the principal management objective of the refuge. Prescribed burning is used as a management tool for the improvement of habitat. Limited amounts of timber harvesting occur as part of the management program. Public use and access to the refuge are restricted for the protection of the crane.

The Noxubee National Wildlife Refuge, in east-central Mississippi, consists of approximately 47,000 acres, of which 91 percent are forested. The refuge also contains two lakes and three green-timber reservoirs. The primary management

objective of the refuge is to provide wintering habitat for migratory waterfowl. Other objectives include providing habitat for the endangered red-cockaded woodpecker and for the variety of wildlife species native to east-central Mississippi. Approximately 6,000 acres a year are treated with prescribed burning in order to improve wildlife habitat, reduce wildfire hazards, and to visually enhance certain forest stands. Various types of harvesting activities on approximately 2,000 acres annually allow refuge managers to provide and maintain a diversity of habitat. More than 100,000 visitors a year enjoy fishing, hunting, camping, hiking, wildlife photography, and wildlife observation on the refuge's lands.

The Hillside, Mathews Brake, Morgan Brake, Panther Swamp, and Yazoo National Wildlife Refuges comprise the Yazoo National Wildlife Refuge Complex in the Delta region of west-central Mississippi. This complex consists of almost 61,000 acres, 39,000 acres of which are forested. The principal management objective of the refuge is to provide wintering habitat for migratory waterfowl in the Mississippi flyway including provision of wood duck nesting and rearing habitat. Silvicultural activities such as limited timber harvests, cull-tree removal, and regeneration of disturbed sites help fulfill the overall refuge management objective. Approximately 32,000 visitors a year enjoy such activities as hunting, fishing, and wildlife observation on the Yazoo National Wildlife Complex.

Mississippi Department of Wildlife, Fisheries, and Parks

In July of 1989, the Mississippi Department of Wildlife Conservation merged with the Bureau of Parks to become the Department of Wildlife, Fisheries, and Parks (MDWFP). Management, conservation, development, and protection of the state's wildlife and marine resources and their habitats are the main emphasis of the Department's mission. The MDWFP manages eight state-owned wildlife management areas (WMA) totaling 87,000 acres. An additional 800,000 acres of WMA are managed in cooperation with various industry owners and governmental agencies. Each year, approximately 400,000 resident licensed sportsmen and 125,000 non-resident licensed sportsmen participate in hunting, fishing, and trapping activities on Mississippi's public and private lands. Of the more than 7 million man-days spent pursuing hunting activities in Mississippi each year, more than 160,000 occur on the state's WMA's. In addition, more than 1.5 million Mississippians annually participate in nonconsumptive wildlife activities such as nature photography or observation, many of which take place on the WMA's.

Forest management goals and activities are determined by the needs of the wildlife community of specific WMA's. Silvicultural activities, such as prescribed burning and timber harvesting, are used to meet specific wildlife management objectives. The MDWFP has a memorandum of understanding with the Mississippi Forestry Commission to assist with forest management and fire detection and suppression.

The Parks and Recreation Division of the MDWFP administers 27 parks throughout the state. These parks encompass approximately 20,000 acres of state-owned or leased lands. The goal of the Parks and Recreation Division is to provide high-quality recreational opportunities through well-managed park lands, water, facilities, programs and visitor services. In 1988, approximately 500,000 overnight visitors and 4 million day visitors enjoyed recreational activities in Mississippi's state parks.

Summary and Concluding Comments

Mississippi's forest industry is an important component of the state's economy. Indeed, more than 57,000 Mississippians were employed by forest industry in 1988. Additionally, economic multipliers indicate that the forest industry, as compared to other manufacturing industries, has the greatest overall impact on the state's economic output, income, and employment.

Recent forest industry developments, such as the construction of a new pulp mill at Grenada and a major pulp mill expansion at Columbus, demonstrate the potential for forest industry expansion in Mississippi. Furthermore, the furniture industry in northeastern Mississippi has grown impressively over the last decade. In recent years, timber markets have been extremely competitive in the southern half of the state, indicative of a situation in which the forest industry is closely utilizing current regional timber production capacity. However, opportunities for forest industry expansion exist in the southern half of Mississippi, especially in secondary manufacturing.

Timberland ownership patterns have influenced the characteristic of the state's timberland resource, and will continue to do so in the future. Nonindustrial private forest landowners (NIPF) own nearly 70 percent—11.7 million acres—of Mississippi's 17 million acres timberland. Another 20 percent—3.3 million acres—of the timberland resource is owned or controlled by forest industry. Forest management activities of these two sets of landowners will largely dictate the yield of forest products from Mississippi's timberlands.

Forest industry's forest management objectives focus primarily on the supply of raw materials for their manufacturing facilities, while NIPF landowners may have multiple land-owning objectives which often include timber harvesting. Recent survey results of Mississippi's NIPF landowners indicate that more than 70 percent of the timberland belongs to owners who are primarily interested in current or future income, and that 68 percent of NIPF timberland will be harvested in the future (Baird and Doolittle, 1988). Other research suggests that nearly 100 percent of NIPF timberland will be harvested in the future because landowners' objectives change as timber matures (Stone, 1970).

Increasing recreational use of public forest resources, along with developing environmental activism and constraints, may result in fewer acres available for commercial timber production. Perhaps the greatest potential for increasing forest productivity is enhanced forest management activities on the state's timberlands, which are producing only 46 percent of potential for fully-stocked natural stands. Forest management treatments, such as timber stand improvement of overstocked stands and reforesting poorly-stocked stands, can greatly increase Mississippi's timberland productivity. However, many management activities that increase productivity require financial investments by landowners.

Nonindustrial private landowners are the key targets to ensuring Mississippi's long-term timber supply. Traditionally, these landowners have been reluctant to invest heavily in timber production. Perhaps this reluctance is justified. Teeguarden (1985) identified seven potential barriers to investment in private forestry based on previous studies regarding the effects of public policy on private forestry investment. These barriers include: *(1)* the perception of low rates of return relative to other investments; *(2)* lack of investment capital; *(3)* lack of liquidity and long payback periods; *(4)* income, property, and estate taxes; *(5)* lack of knowledge about benefits of forest investments, technical assistance, future markets, and price trends; *(6)* high risk and uncertainty about forest investment payoffs; and (7) diseconomies of scale, placing the small landowner at a disadvantage in production costs, marketing, and cost of capital.

From 1952 to 1984, softwood net annual growth exceeded timber removals, and softwood inventory had been increasing in Mississippi. In the future this may no longer be the case; softwood inventory is expected to decrease over the next 30 years. Hardwood supply projections are even more grim. Hardwood inventory is expected to decrease by a third by the year 2030 (USDA Forest Service, 1988).

Limited timber supply has the potential to curtail further economic development of Mississippi's forest industries. Teeguarden (1985) identified public policy tools that have been developed to lower investment barriers and stimulate forestry investments. Public policy tools currently having positive impacts on forestry investment in Mississippi include the state's Forest Resource Development Program; the federal Forestry Incentives Program; tax credits and rapid amortization of reforestation costs; technical assistance to timberland owners; fire, insect, and disease detection and control; annual income payments for those enrolled in the federal Conservation Reserve Program; price reporting and marketing services; public research and development; cooperative extension services; and university training of professional forestry managers. These public policy tools are making a difference in how NIPF land is being managed. A continued public policy emphasis encouraging intensive and environmentally sound forest management is needed. Many of the trees that will be harvested in 2020 will be planted today.

Mississippi's economy has a vital stake in its forest products industry. Nonindustrial private forest landowners will largely determine the long-term supply of raw material to that industry. Federal and state public policy tools encourage the wise management of forest resources, and if Mississippi's forests are to meet the state's timber and nontimber demands, public policy will need to address continued encouragement and intensification of environmentally sound forest management practices in Mississippi. It is a challenge that must be accepted if one of the key factors in the Mississippi economy is to continue to expand.

GLOSSARY[4]

commercial species — Tree species currently or prospectively suitable for industrial wood products. Excluded are non-commercial species.

cord — A stack of wood measuring 4 feet by 4 feet by 8 feet long; 128 cubic feet (wood, bark, and air).

cubic feet — Volume unit of measurement; 1 foot by 1 foot by 1 foot = 1 cubic foot.

d.b.h. — Diameter at breast height; diameter of a tree, outside bark, at 4.5 feet above ground.

forest types — A classification of forest land based upon those tree species forming a plurality of live-tree stocking. Mixed types that in combination contain a majority of hardwood stocking are hardwood types.

forest land — Land at least 16.7 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for non-forest use.

forest land ownership classifications —
National Forest — Federal lands legally designated as national forests or purchase units, and other lands under the administration of the USDA Forest Service.

Other Public — Other federal lands, including Indian reservations; state, county, and municipal forest lands.

Forest Industry — Lands owned by individuals or business organizations operating wood-using plants. Includes lands leased to forest industry.

Non-industrial private forests (NIPF) — Other private lands including farmer, corporate (other than forest industry), and individual forest lands.

growing stock trees — Live trees of commercial species excluding rough and rotten cull trees. Includes sawtimber trees, poletimber trees, and saplings. Rough and rotten trees are excluded. Growing stock volume is for those growing stock trees at least 5.0-inches in d.b.h. to a 4.0-inch top.

growth-removal ratios — Average net annual growth of timber volume divided by average net annual removal. Ratios greater than 1.0, equal to 1.0 and less than 1.0 indicate growth in excess of removal, growth equals removal, and growth less than removals, respectively.

hardwoods — Usually broadleaf trees that lose their leaves in the fall. A conventional term for the timber of broadleaved trees, and the trees themselves.

input-output model — An input-output model is an economic analytical tool based on the interrelationships of industry sectors that compromise the total regional economy.

multipliers — Multipliers derived from input-output models measure economic effects resulting from introducing new industries or changing existing industries of a region's economy.

natural stand — Stands with no evidence of artificial regeneration (planting). Includes those stands established by seed tree regeneration methods.

plantations — A man-made forest; a crop or stand raised artificially, either by sowing or planting.

poletimber trees — Live trees of commercial species 5.0 to 8.9 inches d.b.h. for softwoods and 5.0 to 10.9 inches for hardwoods.

productivity — Productivity of timberland is an estimate of the inherent capability of the land to grow crops of industrial wood based on fully-stocked natural stands. Productivity is measured in units of cubic feet of wood per acre per year.

pulpwood — Wood that is cut for manufacture into paper products, which must first be converted to wood pulp during primary manufacture. Certain roundwood products destined for chip-n-saw, waferboard, oriented strand board, and other uses of small diameter trees are often bought and sold in units of cords and thus are reported as pulpwood in severance tax records.

roundwood — Logs, bolts or other round sections cut from trees for industrial or consumer uses. Wood is unprocessed in this form.

sawtimber trees — Growing-stock trees that contain at least a 12-foot saw log in the butt 16 feet and meet regional specifications for freedom of defect. Softwoods must be at least 9.0-inches in d.b.h. and hardwoods at least 11.0- inches in d.b.h.

SIC (Standard Industrial Classification) — A system of classifying establishments into industries, based on considerations such as similarity of manufacturing processes, types of materials used, types of customers, etc. SIC codes related to forestry include:

SIC 24 - Lumber and wood products, except furniture. Includes establishments primarily engaged in cutting timber and pulpwood; merchant sawmills, lath mills, cooperage stock mills, planing mills, and plywood mills and veneer mills engaged in producing lumber and wood basic materials; and establishments engaged in manufacturing finished articles made entirely or mainly of wood or related materials.

SIC 25 - Furniture and fixtures. Includes establishments primarily engaged in manufacturing household, office, public building, and restaurant furniture; and office and store fixtures.

[4] Glossary is based in part on definitions found in Donner and Hines, 1987; Kelly and Sims, 1989; Murphy, 1978; O'Laughlin and Williams, undated; Porterfield et al, 1979; and Smith, 1962.

SIC 26 - Paper and allied products. Includes establishments primarily engaged in the manufacture of pulps from wood and other cellulose fibers, and from rags; the manufacture of paper and paperboard; and the manufacture of paper and paperboard into converted paper products.

softwoods — Coniferous trees, usually evergreen, with needle or scale-like leaves.

stands - A community of trees possessing sufficient uniformity in relation to species, age, and spatial arrangement, or condition to be distinguishable from adjacent communities.

stumpage - The value of timber as it stands uncut.

timber stand improvement - Those treatments of stands that have as their objective the improvement of the existing stand, regulation of growth, and provision of early financial returns, without any effort directed at regeneration.

timberland - Forest land that is producing, or capable of producing, crops of industrial wood and not withdrawn from timber utilization.

value added - Value of shipments less the cost of materials, parts, supplies, fuel, goods purchased for resale, energy, and contract work used in production. Value added represents the income available for workers and business owners.

Literature Cited

American Pulpwood Association. (Annual). Wood fiber forecast for South. APA Transportation Committee. Jackson, MS.

Baird, A. W., and M. L. Doolittle. 1988. Nonindustrial private forest owners and resources in Mississippi. Final Report to USDA Forest Service FS-SO 4801-3-88-10. 42 p.

Carpenter, E. M. 1985. Ownership change and timber supply on nonindustrial private forest land. USDA Forest Service Research Paper NC-265. 14 p.

Donner, B. L., and F. D. Hines. 1987. Forest statistics for Mississippi counties, 1987. Resource Bulletin SO-129. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 79 p.

Flick, W. A., and L. D. Teeter. 1988. Multiplier effects of the southern forest industries. Forest Products Journal, Nov.-Dec. 1988, 38(11/12):69-74.

James, L. M. 1951. Mississippi's forest resources and industries. Forest Resource Report No. 4. USDA Forest Service Southern Forest Experiment Station, 92 p.

Kelly, J. F., and F. D. Hines. 1987a. Forest statistics for north Mississippi counties - 1987. Resource Bulletin SO-122. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 39 p.

Kelly, J. F., and F. D. Hines. 1987b. Forest statistics for south Mississippi counties - 1987. Resource Bulletin SO-124. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 34 p.

Kelly, J. F., and F. D. Hines. 1987c. Forest statistics for Mississippi Delta counties - 1987. Resource Bulletin SO-126. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 34 p.

Kelly, J. F., and F. D. Hines. 1987d. Forest statistics for central Mississippi counties -1987. Resource Bulletin SO-127. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 34 p.

Kelly, J. F., and F. D. Hines. 1987e. Forest statistics for southwest Mississippi counties - 1987. Resource Bulletin SO-128. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 33 p.

Kelly, J. F., and M. Sims. 1989. Forest Resource of Mississippi. Resource Bulletin SO-147. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 63 p.

Lee, K. C. 1986. A study of the Mississippi input-output model. Mississippi Research and Development Center, Jackson, MS, 45 p. plus appendices.

Mississippi Cooperative Extension Service. (Annual). Harvest of forest products, 1978-1989. Mississippi State University, MS.

Mississippi Cooperative Extension Service. 1990. Farm value of cotton and soybeans, Mississippi, selected years. Unpublished data. Mississippi State University, MS.

Mississippi Employment Security Commission. 1988. Mississippi covered employment and wages, 1987. (Unnumbered publication) Jackson, MS.

Mississippi Employment Security Commission. 1989. Mississippi covered employment and wages, 1988. (Unnumbered publication) Jackson, MS.

Mississippi Forest Commission. 1990. Specific data sheets on Mississippi forest industries. Unpublished data. Jackson, MS.

Murphy, P. A. 1978. Mississippi forests - Trends and outlook. Resource Bulletin SO-67. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 32 p.

O'Laughlin, J., and R. A. Williams. (Undated). Forests and the Texas economy. B-1596. Texas A&M University, College Station, TX, 64 p.

Porterfield, R. L., T. R. Terfehr, and J.E. Moak. 1979. Forestry and the Mississippi economy. Bulletin 869. Mississippi Agriculture and Forestry Experiment Station, Mississippi State, MS, 51 p.

Smith, D. M. 1962. The practice of silviculture. Seventh Edition. John Wiley and Sons, Inc., New York. 578 p.

Stone, R. N. 1970. A comparison of woodland owner intent with woodland practice in Michigan's Upper Peninsula. Ph.D. Thesis. University of Minnesota. 115 p.

Straka, T. J. 1985. Nonindustrial private forest timber output: a positive projection system. Resource Management and Optimization 3(3): 209-217.

Straka, T. J., H. W. Wisdom, and J. E. Moak. 1984. Size of forest holding and investment behavior of nonindustrial private owners. Journal of Forestry 82(8):495-496.

Teeguarden, D. E. 1985. Effects of public policy on forestry investments. P. 215-240 in Investments in forestry resources, land use, and public policy. Westview Press, London.

USDA Agricultural Stabilization and Conservation Service. 1990. Conservation reserve program - State totals - Signups 1 through 9. Unpublished data. USDA Agricultue Stabilization and Conservation Service, Mississippi state office. Jackson, MS.

USDA Forest Service. (Annual). Southern pulpwood production reports, annual. Southern Forest Experiment Station, New Orleans, LA (even years), and Southeastern Forest Experiment Station, Ashville, NC (odd years).

USDA Forest Service. 1988. The South's fourth forest: Alternatives for the future. Forest Resource Report No. 24. USDA Forest Service, Washington, DC, 512 p.

USDA Forest Service. 1989. Unpublished data. Southern Forest Experiment Station, Forest Inventory and Analysis, Starkville, MS.

USDA Forest Service. 1989a. Personal communication. Southern Forest Experiment Station, Forest Inventory and Analysis, Starkville, MS.

USDC Bureau of the Census. 1985. 1982 Census of manufactures, Geographic area statistics, Mississippi. MC82-A-25. Washington, DC.

USDC Bureau of the Census. 1987. 1984 Annual survey of manufactures, Origin of exports of manufactured products. M84-AS-5. Washington, DC.

USDC Bureau of the Census. 1988. 1986 Annual survey of manufactures, Geographic area statistics. M86(AS)-3. Washington, DC.

USDC Bureau of the Census. 1989. Analytical report series, Exports from manufacturing establishments: 1985 and 1986. AR86-1. Washington, DC.

USDL Bureau of Labor Statistics. 1988. Employment and wages, Annual averages, 1987. Bulletin 2314. Washington, DC.

Van Sickle, C. C., and D. D. Van Hooser. 1969. Forest resources of Mississippi. Resource Bulletin SO-17. USDA Forest Service Southern Forest Experiment Station, New Orleans, LA, 34 p.

Williams, M. 1980. Products of the forest: Mapping the census of 1840. Journal of Forest History 24(1): 4-23.

APPENDIX A

Table A1. Forest production by product class and species group, Mississippi, 1978-1989.[1]

Year	Sawtimber[2]			Pulpwood[3]		
	Pine	Hardwood	Total	Pine	Hardwood	Total
	(million board-feet)			(thousand cords)		
1989	1,444	452	1,896	4,037	3,212	7,249
1988	1,355	416	1,771	3,431	2,532	5,963
1987	1,277	523	1,800	3,604	2,576	6,180
1986	1,161	375	1,536	3,055	2,063	5,118
1985	937	284	1,221	3,181	1,847	5,028
1984	945	353	1,298	3,071	1,837	4,908
1983	933	288	1,221	2,965	1,799	4,764
1982	802	250	1,052	3,070	1,460	4,530
1981	913	317	1,230	3,280	1,542	4,822
1980	1,161	437	1,598	3,384	1,504	4,888
1979	1,246	425	1,671	3,084	1,574	4,658
1978	1,212	468	1,680	2,742	1,526	4,268

[1] Source: Mississippi Cooperative Extension Service —Annual.

[2] Pine sawtimber includes poles, piling, and plywood logs. Hardwood sawtimber includes veneer logs and crossties.

[3] Pulpwood includes roundwood destined for wood pulp, chip-n-saw, oriented stand board, waferboard, and other uses of smaller diameter trees.

Table A2. Mississippi pulpwood production consumption, 1977-1988.[1]

Year	Pulpwood[2]		
	Production	Consumption	Production less Consumption
	(thousand cords)		
1988	7,235	4,735	2,500
1987	6,955	4,850	2,105
1986	7,129	4,656	2,473
1985	5,674	4,687	987
1984	5,910	4,249	1,661
1983	5,634	4,004	1,630
1982	5,362	3,304	2,058
1981	5,873	3,632	2,241
1980	6,014	3,453	2,561
1979	7,287	3,524	3,763
1978	5,530	3,482	2,048
1977	5,212	3,289	1,923

[1] Sources: Production: USDA Forest Service—Annual; Consumption: American Pulpwood Association—Annual.

[2] Production figures include softwood and hardwood roundwood and chips harvested from Mississippi's forests, and wood chips from mill residues destined for the manufacture of wood pulp in which Mississippi was the state of origination for the raw material. Consumption figures include softwood and hardwood roundwood, wood chips, and mill residues utilized by mills in Mississippi for the manufacture of wood pulp and wood chips used for energy production.

Table A3. Value of selected crops in Mississippi, 1978-1989.[1]

Year	Timber	Cotton	Soybeans
		($ million)[2]	
1989	711	607	232
1988	611	721	379
1987	600	738	279
1986	478	480	205
1985	498	563	375
1984	518	581	464
1983	484	574	462
1982	407	651	530
1981	467	540	470
1980	526	493	480
1979	550	510	743
1978	470	484	547

[1] Sources: Mississippi Cooperative Extension Service—Annual, and Mississippi Cooperative Extension Service, 1990.

[2] Value at first point of delivery.

Table A4. Total employment, total annual wages, and average annual wages of forest products industry employees with comparisons, Mississippi, 1988.[1]

Industry	Employment[2]	Total Annual Wages	Average Annual Wage Per Employee
	(No.)	($ thousand)	($)
Logging Camps and Contractors	3,684	46,273	12,561
Sawmills and Planing Mills	10,650	177,371	16,655
Millwork and Plywood	3,923	73,566	18,752
Other Wood Products	5,613	95,412	16,998
Furniture and Fixtures	24,893	402,691	16,177
Paper and Allied Products	8,269	243,123	29,402
All Forest Related Manufacturing	57,032	1,038,436	18,208
All Mississippi Manufacturing	239,324	4,389,521	18,341

[1] Source: Mississippi Employment Security Commission 1989.

[2] Average monthly employment for those employers covered under the Mississippi Employment Security Law.

Table A5. Timberland area by survey region in Mississippi, 1957, 1967, 1977, and 1987.[1]

Survey Region	Survey Year			
	1957	1967	1977	1987
	(thousand acres)			
Delta	1,917.1	1,493.8	1,476.6	1,388.3
North	4,204.0	4,194.8	4,251.4	4,401.2
Central	3,792.4	3,959.5	3,879.3	4,097.0
South	4,533.4	4,489.1	4,320.7	4,329.0
Southwest	2,746.7	2,754.7	2,756.8	2,766.0
Total	17,193.6	16,891.9	16,684.7	16,981.5
Percent of Total Area	57	56	55	56

[1] Source: Kelly and Sims, 1989.

Table A6. Mississippi's timberland area by ownership class, 1987.[1]

Ownership Class	Area	Percent of Total Timberland	Percent of All Land
	(thousand acres)	(%)	(%)
National Forest	1,212.1	7.1	4.0
Other Public	707.2	4.2	2.3
Forest Industry	3,332.8	19.6	11.0
NIPF	11,729.4	69.1	38.9
All Ownerships	16,981.5	100.0	56.3
All Mississippi[2]	30,176.0		

[1] Source: Adapted from Donner and Hines, 1987, Table 7.

[2] Source: USDA Forest Service, 1988, Appendix 1, Table 1.1.

Table A7. Mississippi's timberland area by ownership class and forest type, 1987.[1]

Ownership Class	Total Area	Forest Type[2]					
		Pine		Oak-Pine			Other
		Planted	Natural	Planted	Natural	Oak-Hickory	Hardwood
	(thousand acres)						
National Forest	1,212	62	432	74	283	233	128
Other Public	707	23	149	21	103	155	256
Forest Industry	3,325	839	535	377	313	763	498
NIPF	11,729	615	2,117	281	2,071	4,326	2,319
All Ownerships	16,973	1,539	3,233	753	2,770	5,477	3,201

[1] Sources: Adapted from Donner and Hines, 1987, Table 7; and USDA Forest Service, 1989.

[2] Pine forest type includes longleaf-slash and loblolly-shortleaf types. Other hardwood forest type includes oak-gum and elm-ash-cypress types. Area does not include approximately 8,000 acres of open land classified as timberland.

Table A8. Mississippi's pine and oak-pine plantation area by ownership class and age class, 1987.[1]

Ownership Class	Forest Type	Age Class[2]							
		(years)							
		5	15	25	35	45	55	Mixed	Total
		(thousand acres)							
National Forest	Pine	4.3	26.4	5.0	13.5	12.4	—	—	61.6
	Oak-Pine	13.1	11.7	—	—	6.8	—	42.3	73.9
Other Public	Pine	11.9	—	4.8	—	—	—	5.8	22.5
	Oak-Pine	9.5	—	5.4	—	—	—	5.7	20.6
Forest Industry	Pine	457.1	145.3	84.0	26.0	6.7	—	119.8	838.9
	Oak-Pine	229.5	57.6	6.1	4.8	—	5.0	74.0	377.0
NIPF	Pine	242.5	102.6	125.0	40.2	11.7	—	92.9	614.9
	Oak-Pine	142.1	19.5	18.5	12.5	—	—	88.5	281.1
All Ownerships	Pine	715.8	274.3	218.8	79.7	30.8	—	218.5	1,537.9
	Oak-Pine	394.2	88.8	30.0	17.3	6.8	5.0	210.5	752.6
	Total	1,110.0	363.1	248.8	97.0	37.6	5.0	429.0	2,290.5

[1] Source: USDA Forest Service, 1989.

[2] Age classes are mid-point values of 10 year ranges. The 5-year age class includes those stands recently harvested and not yet regenerated. Mixed age classes include those planted stands that contain stand components with at least two distinct age classes.

Table A9. Productivity of Mississippi's timberland by ownership class, 1987.[1]

Ownership Class	Actual net growth	Potential net growth	Actual as percent of potential
	(ft^3/A/yr)	(ft^3/A/yr)	(%)
National Forest	56	126	44
Other Public	40	129	31
Forest Industry	57	118	48
NIPF	56	123	46
All Ownerships	56	122	46

[1] Source: USDA Forest Service, 1989.

Table A10. Growing stock volume of Mississippi's timberland by species group, 1957-1987.[1]

Year[2]	Softwood	Hardwood	Total
	(million ft³)		
1957	4,021	6,291	10,312
1967	6,555	6,480	13,035
1977	9,013	8,414	17,427
1987	9,087	10,339	19,426

[1] Sources: Van Sickle and Van Hooser 1969; Donner and Hines 1987, Table 17 (adapted); and USDA Forest Service, 1989.

[2] Minor changes in survey procedures have occurred from 1957 to 1987 that may affect compatibility of data. Although these changes may limit very detailed analyses between survey intervals, general trends and comparisons can be made.

Table A11. Average volume per acre of softwood and hardwood growing stock by ownership class and forest type, Mississippi, 1987.[1]

			Forest Type[2]				
			Pine		Oak-Pine		
Ownership Class		Units	Planted	Natural	Planted	Natural	Hardwood
National Forest	Softwood	ft³/A	1,607	1,761	490	1,117	235
	Hardwood	ft³/A	65	242	409	617	1,060
Other Public	Softwood	ft³/A	996	1,749	1,000	863	128
	Hardwood	ft³/A	242	332	421	589	1,213
Forest Industry	Softwood	ft³/A	604	1,438	210	795	119
	Hardwood	ft³/A	41	162	129	468	832
NIPF	Softwood	ft³/A	845	1,314	259	684	120
	Hardwood	ft³/A	76	192	174	477	927
All	Softwood	ft³/A	746	1,414	277	748	125
Ownerships	Hardwood	ft³/A	59	200	181	495	932

[1] Source: USDA Forest Service 1989.

[2] Pine forest type includes longleaf-slash and loblolly-shortleaf types. Hardwood forest type includes oak-hickory, oak-gum, and elm-ash-cypress types.

Table A12. Average volume per acre of softwood and hardwood growing stock in the sawlog portion of sawtimber by ownership class and forest type, Mississippi, 1987.[1]

			Forest Type[2]				
			Pine		Oak-Pine		
Ownership Class		Units	Planted	Natural	Planted	Natural	Hardwood
National Forest	Softwood	ft³/A	1,114	1,424	275	953	202
	Hardwood	ft³/A	7	85	243	291	666
Other Public	Softwood	ft³/A	766	1,387	765	685	109
	Hardwood	ft³/A	85	180	153	316	787
Forest Industry	Softwood	ft³/A	258	991	119	619	92
	Hardwood	ft³/A	11	50	48	225	486
NIPF	Softwood	ft³/A	458	943	126	490	89
	Hardwood	ft³/A	38	70	73	207	517
All	Softwood	ft³/A	380	1,036	155	559	95
Ownerships	Hardwood	ft³/A	23	74	79	222	531

[1] Source: USDA Forest Service 1989.

[2] Pine forest type includes longleaf-slash and loblolly-shortleaf types. Hardwood forest type includes oak-hickory, oak-gum, and elm-ash-cypress types.

APPENDIX B

Composition of Input-Output Model Sectors[5]

1. **Livestock and Livestock Products** (SIC 013, 025, 021, 0241, 027) — Cotton and cottonseed; poultry and eggs; meat animals; other livestock (milk).
2. **Other Agricultural Products** (SIC 011, 0116, 018, 0191, 081-4, 091, 097) — Food and feed grains; soybeans and peanuts; other crops; forestry and fisheries products; agricultural, forestry, and fisheries services; catfish farming.
3. **Mining** (SIC 13, 14) — Crude petroleum and natural gas; stone and clay mining and quarrying.
4. **Construction** (SIC 15-7) — Construction.
5. **Food and kindred** (SIC 20) — Meat packing, poultry processing, dairy products, food and feed grains processing, bakery products, cottonseed oil mills, soybean oil mills, beverages, miscellaneous food and kindred products, catfish processing.
6. **Textiles** (SIC 22, except 225) — Textile mill products except knitting.
7. **Apparel** (SIC 225, 23) — Knitting mills; apparel, miscellaneous fabricated textile products.
8. **Logging Camps** (SIC 2411) — Logging camps and contractors.
9. **Sawmills** (SIC 2421, 2426) — Sawmills and planing mills; hardwood dimension and flooring mills.
10. **Millwork and Plywood** (SIC 2431, 2435-6) — Millwork; hardwood veneer and plywood; softwood veneer and plywood.
11. **Other Wood Products** (SIC 2434, 2439, 2441, 2448, 2449, 2452, 2491, 2492) — Wood kitchen cabinets; structural wood members; nailed wood boxes and shook; wood pallets and skids; wood containers; prefabricated wood buildings; wood preserving; particle board.
12. **Furniture and Fixtures** (SIC 25) — Household, office, public building, and restaurant furniture; office and store fixtures.
13. **Paper and Allied** (SIC 26) — Pulp, paper, and paperboard mills; miscellaneous paper products.
14. **Chemical and Allied** (SIC 28) — Chemicals and selected chemical products; plastics and synthetic materials; drugs, cleaning, and toilet preparations; paints and allied products.
15. **Rubber and Plastics** (SIC 30) — Rubber and miscellaneous plastic products.
16. **Primary Metals** (SIC 33) — Primary iron and steel manufacturing; primary nonferrous metals manufacturing.
17. **Fabricated metals** (SIC 34) — Metal containers; heating, plumbing, and fabricated structural metal products; screw machine products and stampings; other fabricated metal products.
18. **Machinery and Electric** (SIC 35, 36) — Farm, garden, construction, metal working, special industry, general industrial, and miscellaneous machinery and equipment; office, computing, accounting, and service industry machines; electrical transmission and distribution equipment and industrial apparatus; household appliances; electric lighting and wiring equipment; radio, TV, and communication equipment; electronic components and accessories; miscellaneous electrical machinery, equipment, and supplies.
19. **Transportation Equipment** (SIC 37, 2451) — Motor vehicles and equipment; ship and boat building and equipment; other transportation and equipment; mobile homes.
20. **Miscellaneous Manufacturing** (SIC 27, 29, 31, 32, 38, 39) — Printing and publishing; petroleum refining and related industries; leather and leather products; glass, stone, and clay products; watches, clocks, medical instruments, optical instruments and lenses; miscellaneous manufacturing and supplies.
21. **Wholesale and Retail** (SIC 50, 52, 58) — Wholesale trade; retail trade; eating and drinking places.
22. **Services** (SIC 70, 72, 73, 75, 76, 78-84, 86, 89) — Hotel and lodging places; personal care and repair services; business services; automobile repair and services; amusement; health services; professional services; educational services; social and non-profit organizations.
23. **Finance, Insurance, and Real Estate** (SIC 60, 65, 67) — Finance and insurance; real estate and rental.
24. **Transportation** (SIC 41, 44) — Transportation and warehousing.
25. **Communication and Utilities** (SIC 48, 49) — Communication, electrical, gas, water, sanitary services and supplies.

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[5] Adapted from Lee, 1986.

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46456/2M

Bulletin 972 • January 1991

The Costs of Cotton Harvesting Systems in the Mississippi Delta

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The Costs of Cotton Harvesting Systems in the Mississippi Delta

Introduction

The harvesting component of cotton production is complex and expensive. Managing the production of a cotton crop to achieve an early and timely harvest can lead to improved returns [9, 10]. An economic evaluation of cotton harvesting must consider production techniques and the resulting effect on yields, maturity, and timeliness of harvest. In recent years, evaluations have focused on these factors while taking the organization and means of the harvest as given. However, there have been significant technological changes in cotton harvesting and handling during the past two decades.

The introduction of module builders in the early 1970's has impacted seed cotton handling and ginning [1, 11]. A 1984 study discussed potential impacts of four-row harvesters, but was largely speculative [2]. The increased use of four-row pickers since 1985 has also been associated with an increase in the use of boll buggies in the Delta. A boll buggy is a tractor-towed cotton basket and serves the same function as a grain cart when combines are used to harvest crops.

Performance rates (the time required to harvest one acre, measured in hours per acre) of these more advanced cotton harvesting systems have not been updated in the Mississippi Agricultural and Forestry Experiment Station/Mississippi Cooperative Extension Service (MAFES/MCES) cost of production estimates since 1975 [3, 4, 5, 6, 12]. Thus, an in-depth study of cotton harvesting systems in the Mississippi Delta was initiated in 1988. The purpose of this paper is to provide physical and economic data to cotton producers for decision making relative to cotton harvesting.

Methodology

To meet the objectives of the study, much information had to be collected and analyzed. First, the harvest operations on a sample of cotton farms were observed to obtain data from which performance rates could be calculated. Second, 16 harvesting systems were developed to allow comparisons of old and new technology. Third, the costs of each of these representative cotton harvesting systems were estimated. These components are discussed in the following sections.

Performance Rates

MAFES contracted with the Mississippi Agricultural Statistics Service to provide enumerators to assist in collecting cotton harvesting data. Enumerators spent at least one day with each of 42 growers collecting data. Detailed data concerning the time associated with each component of the harvest was obtained and are shown in Table 1. From the 42 farms, observations were made on 104 cotton pickers, 68 module builders, 13 boll buggies, and numerous trailers. Data from these observations were organized and used to compute average first-pick performance rates for each harvest system. Also, information was collected about the number and job description of personnel involved, distance to gins, ginning rates, length of harvest day, and harvest dates, (Appendix Table 1).

The performance rate for second pick was not observed in this study. Second pick performance rates were calculated by adjusting published performance rates with observed turn time, turn row time, dump time, and down time. Farmers reported two dumps per day for second pick, and this figure was used to develop second pick performance rates.

Harvesting Systems

The systems analyzed in this study were not actual systems found on farms. Most observed systems had a mixture of two-row pickers of various ages. All but

Table 1. Components of harvest cycle observed.

Number	Item
1	Picking
2	Travel to dump site
3	Dump, trailer
4	Dump, module builder
5	Dump, boll buggy
6	Return to field
7	Clean (picker, heads, etc.)
8	Breakdown
9	Other (lunch, rest stop, etc.)
10	Turn time

three farms using four-row harvesters were also using two-row harvesters. This study was designed to allow cost comparisons between various cotton harvesting systems, with emphasis on alternative picker ages and seed cotton handling equipment. Sixteen harvesting systems were developed and represent old and new technology for both two-row and four-row pickers.

Data were obtained from two-row cotton pickers ranging in age from 1972 models to 1988 models. The two-row pickers were divided into three groups: those manufactured before 1982, those manufactured from 1982 to 1985, and those manufactured from 1986 through 1988. Trailers and module builders were used on farms having two-row pickers, but boll buggies were not used on these farms.

A specific attempt was made to include numerous four-row pickers in this study, because observed performance rates for these machines operating in Mississippi have not been available. Field observations of 23 four-row cotton pickers were obtained, constituting 22.1 percent of all machines in this study. An unpublished study of farm organization and structure in the Delta area of Mississippi conducted in 1989 found that 17.6 percent of all cotton pickers were four-row machines.

The four-row pickers observed were 1981 through 1988 models. There were no four-row pickers found on farms that used cotton trailers exclusively. All 13 boll buggies observed in the study were being used in support of four-row pickers.

Harvesting Costs

The total cost of a harvesting system is defined as the sum of variable and fixed costs that are incurred while cotton is picked, handled, and hauled to the gin. Variable costs are comprised of repairs and maintenance, diesel fuel, and labor. Fixed cost was estimated as the annuity value of the initial investment over the machine's economic life at an annual interest rate of 10 percent. The costs of first and second picks are calculated separately and added together to derive total cost per year. This total cost is divided by acres picked (first pick only) to arrive at an annual cost per acre.

Before the cost of the cotton harvest system can be estimated, the length of the harvest day must be considered. Data obtained by the field enumerators in this study indicated an average time of 8.76 hours per harvest day. A study reported in 1990 [7] reported 8.71 harvest hours per day at Stoneville, Mississippi, making use of observed weather data for the period September 25 through October 22. This study assumes 8.7 hours per day during first and second picks.

Another important factor is the number of days fit for harvesting during the first pick. The harvest initiation date is influenced principally by planting dates, production practices, and weather during the growing season. Completion of the first harvest is a function of the number of pickers available, their performance rates, and weather. Beginning harvest dates usually vary by at least 2 weeks from the South Delta to the North Delta because of differences in planting dates and accumulated DD-60's. Starting dates for harvesting cotton range from September 15 to October 10 at Stoneville, Mississippi. The use of earlier and faster fruiting varieties has generally resulted in earlier harvesting dates in the Mississippi Delta during the last 10 years.

Research on earliness has shown that higher yields and greater profits are obtained if the first harvest is started by September 25 and completed by October 22 [7]. These 28 calendar days have an average of about 18 days suitable for harvest (days fit), Appendix Table 2. This study uses 18 harvest days as the basis for determination of total cotton harvesting costs.

Each machine is assumed to have a known economic life (measured in hours of use). Annual hours available for first pick are derived by multiplying hours per day by days of picking. This number, divided by the performance rate, gives the number of acres that are assumed to be harvested during first pick. It is assumed that second pick is performed on one-half of the first-pick acres. Annual hours of use during second pick are derived by multiplying second-pick acres by the performance rate. The total of first-pick and second-pick annual hours of use divided into lifetime hours of use determines the economic life (in years) of the machine.

Repairs and maintenance over the life of each machine are assumed to be a specified portion of the initial investment. Dividing this amount by years of life gives the annual cost estimate for repairs and maintenance. Annual fuel cost is determined by multiplying the annual hours of use by the fuel use rate (gallons per hour) by the price of diesel fuel ($0.90 per gallon).

Labor use for seed cotton handling differed greatly from farm to farm. Full-time, or permanent, laborers are utilized throughout the farming year to operate tractors and harvesters. In addition to the picker operator, most farmers reported one other permanent laborer used primarily for spotting trailers and assisting in picker cleaning and maintenance. If module builders are included in the system, the module operator is a permanent laborer. If a boll buggy is included in the handling system, this laborer is also considered to be a permanent employee. Temporary labor is employed only during the harvest

season to assist in loading and tromping trailers, picking up spilled cotton, and staging and covering modules. The number of temporary laborers varied widely from farm to farm. However, two temporary laborers per farm are assumed in this study. Wage rates used in this study are as follows: picker operator, $6/hour; temporary labor, $4/hour; permanent labor, $6/hour; and supervisor, $10/hour. Each type is paid for 11 hours per day.

Field handling of seed cotton is done through some combination of trailers, module builders, and boll buggies. Farmers in this study dumped the first hour's picking and one to three additional dumps per day on trailers if the module was tied up. Trailer use associated with systems having both modules and boll buggies was slightly lower. All producers cooperating in this study reported sufficient trailers to handle 4 to 6 days of harvest. Many of the trailers were never needed, as usual trailer turn around from the gin was reported to be 36 to 48 hours. The number of trailers provided for each system is sufficient to handle 2.25 days of that portion of harvest which is dumped on trailers. For systems with trailers only, this constitutes the entire harvest for 2.25 days.

Each module builder and boll buggy has a tractor operating with it during the entire day. Two hours of tractor use per day are added to those systems using trailers only. Every 2 days, a trailer is hauled to the gin by a pickup truck. The hauling cost is assumed to be $0.30 per mile for a 16-mile round trip. Modules are assumed to be picked up by the gin at no cost to the producer. Gin rebates for modules are not included in this study. Information concerning purchase price, repair cost percent, lifetime hours of use, and fuel use rates that were used in this study are presented in Appendix Table 3.

Results

Seed cotton handling systems used by producers in the Delta area of Mississippi are extremely varied, ranging from complete dependence on trailers to the use of module builders, boll buggies, and a harvesting supervisor directing activities with radios. The most common handling system observed in the study utilized module builders and trailers for two-row or four-row harvesters. As previously stated, the use of boll buggies was observed only at farms using four-row harvesters.

The observed speed of two-row pickers ranged from 2.1 to 3.2 miles per hour for older pickers and from 2.3 to 3.5 miles per hour for newer pickers. The performance rates for the three age groups of two-row pickers and associated cotton handling equipment are presented in Table 2. Newer harvesters are able to pick more acres per time period than older machines, and thus have lower (more efficient) performance rates. The data also indicate that the inclusion of module builders in the cotton handling system improves (lowers) performance rates. This improvement is greater for newer harvesters.

Table 2. Performance rates of 2-row cotton pickers, three age groups and various cotton handling systems.

Item	Before 1982	1982-1985	After 1985
	hours per acre		
First pick			
Trailers	0.68	0.56	0.55
Modules and trailers	0.65	0.52	0.50
Modules, boll buggies and trailers	N.O.[1]	N.O.[1]	N.O.[1]
Modules, trailers and supervisor	N.O.[1]	N.O.[1]	0.47[1]
Second pick[3]	0.44	0.36	0.35

[1] Not observed.
[2] Two observations.
[3] Derived from published speeds and modified by observed turn time, turn row time and down time. All cotton dumped on trailers.

The observed speed of four-row pickers averaged about 3.2 miles per hour for older pickers and about 3.65 miles per hour for newer pickers. The performance rates of four-row pickers in two age categories are presented in Table 3. Again, newer machines are more efficient than older machines. The use of boll buggies also improved performance rates of four-row cotton pickers.

Once performance rates are estimated, it is possible to determine the acres that any given picker can harvest in one day or during a given season. Information for three classes of two-row pickers with

Table 3. Performance rates of 4-row cotton pickers, two age groups and various cotton handling systems.

Item	1981-1986	After 1986
	hours per acre	
First pick		
Trailers	N.O.[1]	N.O.[1]
Modules and trailers	0.26	0.25
Modules, boll buggies and trailers	0.24	0.22
Modules, boll buggies, trailers and supervisor	N.O.[1]	0.20[2]
Second pick	0.17	0.15

[1] Not observed.
[2] Two observations.
[3] Derived from published speeds and modified by observed turn time, turn row time and down time. All cotton dumped on trailers.

two cotton handling systems and two classes of four-row pickers with two cotton handling systems is presented in Table 4. The acreage harvested in 18 harvest days is used to represent a long-run average situation in this analysis. The components of the first 12 harvest systems that were developed are reported in Table 5. The cost estimates for these 12 systems are presented in Table 6. A discussion of each system follows.

Table 4. Acres harvested during first pick.

Item	Perf. rate	Acres/ 8.7 hr/day	Acres in 18 days
1978 2-row picker + trailers	.68	12.79	230.3
1978 2-row picker, module builder, + trailers	.65	13.38	240.9
1983 2-row picker + trailers	.56	15.54	279.6
1983 2-row picker, module builder, + trailers	.52	16.73	301.2
1988 2-row picker + trailers	.55	15.82	284.7
1988 2-row picker, module builder, + trailers	.50	17.40	313.2
1984 4-row picker, module builder, + trailers	.26	33.46	602.3
1984 4-row picker, module builder, boll buggy, + trailers	.24	36.25	652.5
1988 4-row picker, module builder, + trailers	.25	34.80	626.4
1988 4-row picker, module builder, boll buggy, + trailers	.22	39.55	711.8

Table 5. Components of selected cotton harvesting systems.

System	Picker		No.	No. module	No. boll	Harvest support labor	
Number	Year	No.	trailers	builders	buggies	Perm.	Temp.
2-Row Pickers							
1	1978	2	8	0	0	1	2
2	1978	2	3	1	0	1	2
3	1983	2	10	0	0	1	2
4	1983	2	3	1	0	1	2
5	1988	2	13	0	0	1	2
6	1988	2	3	1	0	1	2
4-Row Pickers							
7	1984	1	3	1	0	1	2
8	1984	1	2	1	1	2	2
9	1988	1	3	1	0	1	2
10	1988	1	2	1	1	2	2
11	1984	2	4	1	1	2	2
12	1988	2	4	1	1	2	2

Systems 1 and 2

These systems utilize two older two-row harvesters. System 1 has eight 12-bale trailers and three laborers for cotton handling, as indicated in Table 5. As shown in Table 6, System 1 can harvest 460 acres during the first harvest. Harvesting the cotton crop was estimated to cost $83.30 per acre when all costs of the system are totaled and averaged over the 460 acres.

System 2 also has two older two-row pickers and three laborers, but one module builder is added and the trailers are reduced from eight to three. This system results in a slight improvement of the performance rate for the old pickers, allowing acres picked to increase to 482 acres. However, about a $4 per acre increase in picking cost is estimated for System 2 as compared to System 1.

Systems 3, 4, 5 and 6

As shown in Table 6, when a module builder is substituted for trailers the total harvest cost per acre declines for 1983 harvesters (Systems 3 and 4) and 1988 harvesters (Systems 5 and 6). The use of a module builder instead of trailers results in improved performance rates for both pickers. Unlike the results for Systems 1 and 2, these improved performance rates result in reduced picking costs per acre. The module builder is able to replace seven trailers in System 3 and ten trailers in System 5. Thus, a greater reduction in per-acre cost is obtained with the 1988 pickers than with the 1983 pickers.

Systems 7 and 8

These two systems have one 1984 four-row cotton harvester instead of two two-row harvesters. System 7 utilizes one module builder and three trailers. System 8 has one module builder, one boll buggy, and two trailers. Farmers with boll buggies reported less need for trailers, and field observations confirmed this. A cost analysis of a trailers-only system with four-row pickers is not included, because no such system was observed on farms surveyed in this study.

The cost of System 8 is almost $8 per acre more than System 7 (Table 6). The addition of the boll buggy improves the performance rate (acres picked increases from 602 to 653 acres), but it also increases per-acre picking costs. When only one trailer is replaced by the

Table 6. Harvest costs per acre, total harvest system (picking and handling).

System number	Number pickers	Picker age	Acres harvested in 18 days	Total harvest cost
2-Row Pickers				*$/acre*
1	2	1978	460.6	83.30
2	2	1978	481.9	87.27
3	2	1983	559.3	89.92
4	2	1983	602.3	87.86
5	2	1988	569.5	92.26
6	2	1988	626.4	84.98
4-Row Pickers				
7	1	1984	602.3	75.50
8	1	1984	652.5	83.31
9	1	1988	626.4	73.36
10	1	1988	711.8	77.49
11	2	1984	1,305.0	67.55
12	2	1988	1,423.6	63.17

Systems 1, 3, and 5 are trailers only.
Systems 2, 4, 6, 7, and 9 are module builders and trailers.
Systems 8, 10, 11, and 12 are module builders, boll buggies, and trailers.

boll buggy (with the additional laborer), the per-acre cost increases.

Systems 9 and 10

These systems are similar to Systems 7 and 8 except for the use of 1988 rather than 1984 pickers. Results show that 1988 pickers have lower per-acre costs than 1984 pickers because of improved performance rates (Table 6). Again, performance rates and annual harvest capacity are further enhanced by the use of a boll buggy in place of a trailer. The increased capacity of System 10 over System 9 is still not sufficient to reduce per-acre harvest cost. However, the cost increase is only about $4 per acre. The per-acre cost increases of the more advanced cotton handling systems are greatest when used with older harvesters.

Systems 11 and 12

These two systems utilize two four-row cotton pickers, one module builder, one boll buggy, and four trailers (Table 5). As shown on Table 6, total per-acre harvest costs are significantly reduced (almost $16 per acre between System 11 and 8 and about $14 per acre between System 12 and 10). This per-acre cost reduction is possible because only two additional trailers are required to support the second four-row picker.

Harvest Supervisors with Radios

Enumerators reported that several farms used radios to communicate with cotton picker operators, module builder operators, boll buggy operators, and other support personnel. This communication capacity allowed equipment coordination, which minimized nonpicking time for cotton harvesters. For example, a supervisor might direct a specific harvester to the quickest dump site; i.e., trailer, module builder, or boll buggy. Data obtained by field enumerators indicated improved performance rates where such supervision existed. Four farms using harvest supervisors with radios were revisited. The data obtained from these followup visits confirmed that such systems were able to harvest more acres per time period than those without supervisors and radios.

The cotton handling systems developed in this study require the addition of one supervisor and six two-way radios. Most of the radios were of the citizen's band type, with an average cost of $150 each and an assumed life of 3 years. The results presented in Tables 7 and 8 indicate that more acres can be harvested at a lower cost per acre where such supervision is a part of the system.

Table 7. Components of cotton harvesting systems with a supervisor.

System No.	Picker Yr.	Picker No.	No. trailers	No. module builders	No. boll buggies	Harvest support labor Perm.	Harvest support labor Temp.
2-Row Pickers							
13	1988	2	3	1	0	1	2
14	1988	3	5	1	0	1	2
4-Row Pickers							
15	1988	2	4	1	1	2	2
16	1988	3	5	1	1	2	2

Table 8. Harvest costs per acre, total harvest system using harvest supervisors and radios.[1]

System Number	Number pickers	Picker age	Acres harvested in 18 days	Total harvest cost $/acre
2-Row Pickers				
13	2	1988	666.4	85.55
14	3	1988	999.6	78.46
4-Row Pickers				
15	2	1988	1,566.0	60.54
16	3	1988	2,349.0	55.13

[1] Data to develop this table were obtained from two farms using 2-row harvesters, one farm using a mix of 2-row and 4-row harvesters, and one farm using 4-row harvesters.

Systems 13 and 14

System 13, Tables 7 and 8, is directly comparable with System 6, Tables 5 and 6, except for the supervisor. Despite an increase of 40 acres harvested during the 18-day harvest season, the total cost of System 13 is $0.57 per acre greater due to the added cost of the supervisor.

System 14 has an additional two-row picker and two more trailers. Where three two-row harvesters are used, the addition of the supervisor results in a total harvest cost of $78.46 per acre, or $7.09 per acre less than System 13 and $6.52 per acre less than System 6. The use of a supervisor is more efficient when using more than two harvesters.

Systems 15 and 16

Results presented in Table 8 show that the impact of a supervisor on harvest costs where two or more four-row pickers are used is also favorable. System 15, two four-row machines with a supervisor, results in a $2.63 per acre savings when compared with System 12, Table 6, as well as an increase of 142 acres (1,424 to 1,566) harvested. System 16, which uses three four-row harvesters, will require the addition of only one trailer. Unlike the two-row systems without a boll buggy, the use of a boll buggy in the four-row systems negates the addition of two trailers. The use of three four-row harvesters reduces per-acre cost even further from $60.54 per acre for System 15 to $55.13 per acre for System 16. Again, the impact of the supervisor is even greater when more than two four-row harvesters are a part of the system.

Limitations

The absence of boll buggies on farms using two-row harvesters prevented the collection of data on how this cotton handling tool impacts the cotton harvest on these farms. However, after observing boll buggies on farms with four-row pickers, it is expected that a boll buggy will reduce nonpicking time for any harvester and may result in faster dump times for two-row machines. Thus, boll buggies will probably improve performance rates and could reduce total harvest costs for two-row harvesters.

The average dump time for four-row pickers on boll buggies was less than the average dump time on either trailers or module builders. Nonpicking time was considerably less when boll buggies were used. To a slightly lesser extent, the same was true where more than one module builder was used. The boll buggy significantly improved performance rates for systems using one, two, or three four-row pickers. No data was collected where one boll buggy supported four four-row machines. Field observations indicate that three 4-row machines is near the limit of efficient use of a boll buggy.

Fifteen farms used more than one module builder. Turn row time was somewhat less on these farms than on farms with only one module builder. However, quantitative differences were not sufficient to allow meaningful conclusions, due to the variations in ages and sizes of pickers.

Conclusions

Newer cotton harvesters are faster than older machines and thus can harvest more acres per time period. The substitution of module builders and boll buggies for trailers improves the performance rates for both old and new harvesters. However, when two-row pickers are used, cost per acre for the complete harvest system declines with the addition of module builders for newer harvesters, but increases for older harvesters. Systems having one four-row picker exhibit an increased cost per acre when boll buggies are added to both old and new harvesters. However, the addition of one more four-row picker to both old and new systems with a boll buggy will substantially lower per-acre harvest costs. The use of harvest supervisors with radios to direct the harvest may have a place on farms utilizing three or more cotton harvesters. The reductions in per-acre harvest costs will be greatest on large cotton farms using four-row pickers with advanced cotton handling systems.

Acknowledgments

The authors wish to express their appreciation to the farmers who agreed to allow data to be collected on their farms. Without their cooperation, this study could not have been done. Also, the efforts of the County Extension Agents who located the cooperating farmers are gratefully appreciated.

Special thanks are due to the enumerators who collected much of the data for this study, and to Mrs. Annette Ray and Mr. Dewitt Caillavet for their patience in organizing and summarizing the data. The authors would also like to thank the reviewers of this paper for their helpful comments.

References

1. Anderson, J. M., and F. T. Cooke. 1974. Conventional systems of handling and ginning seed cotton in the Delta area of Mississippi. MAFES Info. Sheet 1235.
2. Caillavet, D.W., D. W. Parvin, and F. T. Cooke. 1984. Economic analysis of cotton harvesting equipment in the Delta area of Mississippi Proc. Cotton Res. Conf., Atlanta, Ga., Jan. 10, 1984.
3. Cooke, F. T., V. G. Hurt, and J. Sartor. 1983. Estimated costs and returns, crops, Delta area of Mississippi, 1983. MAFES/MCES, Ag. Econ. Rpt. No. 8.
4. Cooke, F. T., V. G. Hurt, and J. Sartor. 1984. Estimated costs and returns, crops, Delta area of Mississippi, 1984. MAFES/MCES, Ag. Econ. Rpt. No. 14.
5. Cooke, F. T., V. G. Hurt, and R. L. Williams. 1986. Estimated costs and returns, cotton, all areas of Mississippi, 1986. MAFES/MCES Ag. Econ. Dept., Pub. No. 1531.
6. Parvin, D. W., J. M. Anderson, F. T. Cooke, S. H. Holder, and J. H. Hamill. 1975. Specific inputs and prices associated with cotton production costs for the Mississippi Delta, 1975. MAFES Bull. 831.
7. Parvin, D. W., and F. T. Cooke. 1990. The mathematics of cotton harvest. 1990 Beltwide Cotton Prod. Conf., Nashville, TN, January 1990.
8. Parvin, D. W., J. G. Hamill, F. T. Cooke, S. H. Holder, and D. M. Cameron. 1978. Budgets for major crops, Delta of Mississippi, 1978. MAFES Info. Bull. 2.
9. Parvin, D. W., J. W. Smith, and F. T. Cooke. 1987. Cost effectiveness of harvesting at the right time. Proc., 1987 Beltwide Cotton Prod. Conf. Highlights of Cotton Prod. Res. Conf., Special Sessions: Cotton Quality Improvement, Short Season Cotton Production Systems, New Developments from Industry, p. 39-40. Dallas, TX, Jan. 4-8, 1987.
10. Parvin, D. W., Jr., J. W. Smith, and F. T. Cooke, Jr. 1987. Cotton harvesting in the Midsouth as it relates to shorter season production systems. Proc., 1987 Beltwide Cotton Prod. Conf. Highlights of Cotton Prod. Res. Conf., Special Sessions: Cotton Quality Improvement, Short Season Cotton Production Systems, New Developments from Industry, p. 79-81. Dallas, TX, Jan. 4-8, 1987.
11. Paxton, K. W., and D. L. Roberts. 1973. Economic feasibility of storing seed cotton in modules under Louisiana conditions. LSU, D.A.E. Res. Rpt. No. 456.
12. Simpson, J. H., and R. L. Williams. 1988. 1988 costs & returns–cotton. MAFES/MCES Ag. Econ. Rpt. 25.
13. Spurlock, S. R., and D. W. Parvin. 1987. A simulation model for cotton harvesting decisions. MAFES, Dept. Ag. Econ., Staff Paper Series No. 69.

Appendix Tables

Appendix Table 1. Miscellaneous data reported by 42 cooperating farmers.

Average number of temporary harvest employees	3.0
Average distance to gin (miles)	6.2
Average gin capacity (bales per hour)	18.0
Average length of harvest day (hours)	
1st pick	8.8
2nd pick	10.5
Average length of harvest season (calendar days)	
1987 - 1st pick	34
2nd pick	18
1988 - 1st pick	32
2nd pick	17
Usual - 1st pick	32
2nd pick	19

Appendix Table 2. Days and hours per day suitable for harvest, Stoneville, Mississippi.

Week	Days	Hours
September 25-October 1	4.74	8.84
October 2-October 8	4.72	8.75
October 9-October 15	4.39	8.66
October 16-October 22	4.04	8.55

Appendix Table 3. Machinery cost factors.

Item	Purchase price	Lifetime use	Repair percent	Fuel use
	$	hours	%	gal/hr
1978 2-Row Picker	47,600	2,000	75	4.5
1983 2-Row Picker	69,200	2,000	75	4.5
1988 2-Row Picker	69,594	2,000	75	4.5
1984 4-Row Picker	118,000	2,000	75	7.5
1988 4-Row Picker	123,000	2,000	75	7.5
Tractor (115-150 HP)	48,855	8,400	52	5.9
Trailer (12 Bales)	3,600	2,400	40	
Module Builder (32 Ft.)	18,000	2,400	80	
Boll Buggy	15,000	2,400	80	
Radio	150	650		

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Bulletin 973 March 1991

PREEMERGENCE

CONTROL OF VELVETLEAF AND COMMON COCKLEBUR IN COTTON

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Preemergence Control of Velvetleaf and Common Cocklebur in Cotton

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Published by the Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine. Edited by Keith H. Remy, Publications Coordinator. Cover designed by Mark Kitchens, Artist.

Preemergence Control of Velvetleaf and Common Cocklebur in Cotton

Summary

Two experiments were conducted from 1987 through 1989 to establish the most effective and consistent preemergence control of velvetleaf and common cocklebur in cotton. Velvetleaf control was more consistent with norflurazon applied preplant incorporated at either 1.0 or 1.5 lb a.i./A followed by diuron.

In 1988, crop injury at 2 weeks varied and was 29% or greater for treatments of norflurazon tank-mixed with diuron and applied preemergence. With one exception, cultivation did not improve velvetleaf control if control without cultivation was greater than 50%.

In 1987, norflurazon applied PPI at 1.5 lb a.i./A followed by fluometuron applied PRE at 1.5 lb a.i./A was the best treatment for common cocklebur control and did not result in crop injury or stand reduction.

Control in 1988 was less than in 1987 and, as a result, cultivation improved common cocklebur control for all treatments evaluated. However, cultivation did not improve control to acceptable levels and was similar to the cultivated untreated check.

Introduction

In a recent survey, velvetleaf (*Abutilon theophrasti* Medik.) was reported to infest 47,000 acres of cotton (*Gossypium hirsutum* L.) in Mississippi (5). Alabama, Missouri, North Carolina, South Carolina and Tennessee have reported velvetleaf as one of the 10 most troublesome weeds in cotton (8). In 1977, Baldwin (1) included velvetleaf in the "difficult to control" group of broadleaf weeds for the Midsouth.

Full season competition of velvetleaf at a density of 16 plants per 40 feet of row caused significant yield reductions (6). When velvetleaf interfered with cotton for 45 days after emergence, lint yield was significantly reduced (18). When kept velvetleaf-free for a period of 4 to 6 weeks after emergence, seed cotton yields were not reduced.

Velvetleaf also serves as a host plant for the pathogens *Phymatotricham omnivorum* and *Verticillium albo-atram* and for insects such as the bollworm [*Heliothis zea* (Boddie)] and tobacco budworm [*Heliothis virescens* (F.)] (17). Extracts from velvetleaf seeds have been shown to adversely affect germination and seedling growth of various crops (9, 11). While not considered a serious pest in cotton in Mississippi, velvetleaf has the potential to increase infestation levels and reduce yields if uncontrolled. Velvetleaf plants produce 750 reproductive structures per season, which provides an abundant source of seed (15). Lueschen and Anderson (16) reported that after 4 years of intensive tillage, 1,300 viable velvetleaf seeds per square yard remained to a depth of 9 inches. Assuming a 25% germination and/or survival rate of these 1,300 seeds, this would produce 325 plants per square yard or 350 times that needed for a significant yield reduction as reported by Chandler (6).

Although velvetleaf is moderately competitive with cotton, and troublesome in only 5 of the 14 cotton producing states, it continues to be a nuisance in certain areas of the Midsouth. Control measures are limited to cultural practices, which are limited in effectiveness (14), or to chemical means. Recently, a biological agent or mycoherbicide, *Fusarium lateritium* Nees ex. Fr., was shown to suppress growth of velvetleaf, but control was only 40% and 46% for postemergence and preemergence applications, respectively (2). Chemical control has not been well documented. However, velvetleaf control with diuron was reported to be better than fluometuron (9, 11), and norflurazon was reported to give only 78% control in a one-year study (11).

One of the more competitive and prevalent weeds in cotton fields today is common cocklebur (*Xanthium strumarium* L.). In 1989, approximately 2.4 million acres of cotton throughout the entire cotton belt were infested with common cocklebur (5). These infestations caused an estimated 11% cotton yield loss, the second highest yield loss caused by any individual weed that year (5). In Mississippi, 500,000 acres were reported infested in 1989, accounting for a yield loss of 13%.

In 1973, Cooley and Smith (7) reported that common cocklebur plants grown with cotton produce 600 to 1000 burs/plant. Each bur is covered with hook-shaped spines, which cling to clothing and machinery, aiding in seed dispersal. Optimum emergence of common cocklebur seedlings occurs when the seed is planted 1 inch or less below the soil surface, however, emergence from depths as great as 4 inches has been documented (7). Each bur contains a lower embryo and an upper embryo, which do not germinate simultaneously (22). This provides common cocklebur with a unique mechanism to perpetuate plants for a minimum of two seasons from a single bur.

Buchanan and Burns (3) reported cotton yield reduc-

tions from two soil types of 20 to 60% with a common cocklebur density of 8 weeds/25 feet of row. Higher weed densities of 48 plants/25 feet of row resulted in losses as high as 90% for both soil types. They reported that competition from common cocklebur had no effect on cotton lint percentage or fiber properties, and that vegetative growth, boll size, and seed size were not as sensitive as cotton yield to common cocklebur competition.

In later studies, it was shown that seed cotton yield decreased with increasing common cocklebur density, but only to a certain limit (21). When densities reached 16 common cocklebur plants per 50 feet of row, yields were not further reduced by higher densities. This curvilinear response indicated intraspecific competition among common cocklebur. Percent yield reductions ranged from 17% to 70% for cocklebur densities ranging from 2 to 32 plants per 50 feet of row (21). In 1987, Snipes et al. (19) reported that the weed-free maintenance period for common cocklebur was 8 to 10 weeks, and competition periods longer than 4 weeks adversely affected yield. These predicted values were more restrictive than previous findings for other species (4, 13).

Early season competition of velvetleaf or common cocklebur with cotton is critical, and height differential of crop and weed is necessary for effective postemergence control in cotton. An effective preemergence herbicide program usually enhances subsequent weed control measures and thus overall weed control in cotton (12, 20). The objective of the research summarized in this bulletin was to establish the most consistent and effective means of preemergence chemical control of velvetleaf and common cocklebur in cotton.

Materials and Methods

Two separate experiments were conducted at the MAFES Delta Branch Experiment Station in Stoneville, MS, from 1987 through 1989. Soil type in the experimental area was a Dundee silty clay loam (fine-silty, mixed, thermic Aeric ochraqualf) with a pH of 6.3 and organic matter content of 1.26%. Individual plots were four 40-inch rows 20 feet in length. A randomized complete block design with four replications was utilized each year. Trifluralin at 0.75 lb a.i. /A was applied preplant incorporated (PPI) to the entire area in March of each year for grass and small-seeded broadleaf weed control. Fertilization, insect control, and other production practices were utilized for optimum cotton productivity.

In the velvetleaf experiment conducted from 1987 to 1989, herbicide treatments were norflurazon applied preplant soil incorporated (PPI) or preemergence (PRE) at 1.0 or 1.5 lb/A; norflurazon applied PPI at 0.5 or 0.75 lb/A followed by norflurazon at equivalent rates applied PRE (herein referred to as a "split" application); norflurazon applied PPI at 0.5, 0.75, 1.0, and 1.5 lb/A followed by diuron at 1.0 lb/A PRE; norflurazon at 0.5, 0.75, 1.0 or 1.5 lb/A tank-mixed with diuron at 1.0 lb/A applied PRE and norflurazon at 0.5 or 0.75 lb/A applied PPI followed by norflurazon at either 0.5 or 0.75 lb/A tank mixed with diuron at 1.0 lb/A.

In the common cocklebur experiments conducted in 1987 and 1988, treatments were: fluometuron applied PRE; norflurazon at 1.5 lb/A applied PPI or PRE; diuron applied PRE; norflurazon at 0.75 lb/A applied PPI followed by norflurazon at 0.75 lb/A, fluometuron, or diuron applied PRE; norflurazon at 1.5 lb/A applied PPI followed by fluometuron or diuron applied PRE; norflurazon applied PPI at 0.75 lb/A followed by fluometuron or diuron tank-mixed with norflurazon at 0.75 lb/A applied PRE; combinations of norflurazon at 1.5 lb/A, fluometuron or diuron in two-way tank-mixes applied PRE; and a three-way tank-mix of each material applied PRE. Fluometuron and diuron rates were 1.5 and 1.0 lb/A, respectively, for all treatments.

Treatments in both experiments were applied with a tractor-mounted compressed air sprayer calibrated to deliver 15 gallons per acre. Treatments to be incorporated were applied broadcast after winter beds were leveled on April 22, 1987; April 21, 1988; and April 20, 1989. In 1987, incorporation was accomplished with one pass of a two-way combination implement set to operate 1 to 2 inches deep. The same method was used in 1988, however, the area was rehipped after shallow incorporation. In 1989, the combination implement was replaced with a flexible-shank cultivator equipped with S-tine shanks and cultivator sweeps operated at a depth of 2 inches. Cotton (DES 119) was planted on April 22, 1987, May 16, 1988, and May 2, 1989. All preemergence applications were broadcast applied on April 23, 1987, May 17, 1988, and May 2, 1989. Cotton emerged on May 1, 1987, May 21, 1988, and May 15, 1989. The common cocklebur experiment was not conducted in 1989, therefore all 1989 dates pertain only to the velvetleaf experiment.

Velvetleaf control was estimated visually at 2 and 8 weeks after PRE application in 1988 and 1989, and at 4 and 6 weeks for all 3 years. Cotton phytotoxicity in the velvetleaf experiment was visually estimated 2 weeks after preemergence treatment in 1988 and 1989, and at 4 weeks in 1987, 1988, and 1989. Common cocklebur control was estimated at 4, 6, and 8 weeks in 1987, and at 2, 4, and 6 weeks in 1988. Crop injury was estimated at 2 weeks in 1988, and at 4 weeks in 1987 and 1988. All visual rating data were based on a scale of 0 to 100 with 0 indicating no con-

trol or crop injury and 100 indicating total control or complete crop kill.

In 1988, two rows of each plot in both experiments were cultivated beginning one day after the 4-week rating and continuing until three cultivations were completed. The 6-week rating was performed separately on the two uncultivated rows and the two cultivated rows. In 1989, the entire velvetleaf experiment was cultivated immediately after the 6-week rating. Therefore, the 8-week rating is after one cultivation. There was no cultivation in either experiment in 1987.

Cotton stand counts were made each year in the velvetleaf experiment by counting all plants along one row 4 weeks after preemergence treatment. Cotton stand counts were made in the cocklebur experiment in 1988 only. After weed removal and at crop maturity, seed cotton determinations were made by mechanically harvesting one row of each plot. Seed cotton yields were determined in 1987 and 1989 in the velvetleaf experiment only.

Analysis of variance was conducted on all data and differences among means were compared at the 5% level of probability using Duncan's Multiple Range Test (DMRT). In 1988, when one-half of each plot was cultivated, each plot was treated as a split-plot. Analysis of variance was conducted and a Least Significant Difference (LSD) at the 5% level of probability was determined to compare cultivated versus uncultivated within each treatment. Arc-sine transformation was conducted on the velvetleaf data prior to analysis on visual ratings from the 4-, 6-, and 8-week rating periods.

Results and Discussion

Velvetleaf

At 2 weeks, cotton injury ranged from 0 to 48% in 1988 (Table 2). All preemergence treatments of norflurazon + diuron resulted in injury greater than 25%. However, those treatments caused 15% injury or less by 4 weeks after treatment. Injury ratings made at 4 weeks after preemergence treatment varied from year to year. In 1987 and 1989, no injury was encountered when norflurazon was applied alone or in any combination. In 1988, norflurazon applied PRE at 1.5 lb/A resulted in 10% phytotoxicity. In 1989, crop injury was greatest when PPI applications of norflurazon at rates greater than 0.75 lb/A preceeded the diuron application. However, injury did not exceed 12%. In 1987, all norflurazon/diuron combination treatments displayed injury symptoms but ratings did not exceed 15%. Overall, injury in 1988 was greater than in 1987 and 1989.

In 1988, the norflurazon plus diuron tank-mix applied preemergence at 1.5 and 1.0 lb/A, respectively, resulted in 29% injury at 4 weeks and reduced cotton stand below that of the untreated check (Table 2).

Table 1. Environmental conditions for 14 days after treatment of various soil applied herbicides for preemergence velvetleaf control in cotton.[1]

Days after preemergence treatment	Year[2]					
	1987		1988		1989	
	Min/Max temp	Rainfall	Min/Max temp	Rainfall	Min/Max temp	Rainfall
	(°F)	(in)	(°F)	(in)	(°F)	(in)
0	79/49	0	92/67	0	75/49	0
1	82/49	0	88/56	0	69/50	0.64
2	78/51	0	86/57	0	62/52	0.10
3	77/52	0	88/59	0	70/60	2.76
4	85/54	0	93/64*	0.16	79/55	0.15
5	92/58	0	85/65	0.14	72/48	0
6	81/49	0	84/61	0.11	74/50	0
7	85/54	0	74/61	0.06	81/59	0.07
7 DAT avg.	83/52	0	85/60	0.07	72/53	0.46
8	92/60*	0	80/61	Trace	79/55	0.01
9	89/62	Trace	78/52	0	71/47	0
10	74/61	0	83/53	0	74/45	0
11	80/61	0	87/59	0	73/50	0.11
12	83/62	0	89/60	0	70/53	1.39
13	83/65	0	90/63	0	73/58*	0
14	82/63	0.70	92/62	0	80/59	0
14 DAT avg.	83/62	0.1	85/59	0	74/52	0.21
Grand avg.	83/57	0.05	82/60	0.035	73/52	0.33

[1]Source: National Oceanic and Atmospheric Administration Midsouth Agricultural Weather Service Center, Stoneville, MS, Station ID 228445 04

[2]* denotes crop emergence.

Other treatments that resulted in significant reductions in stand were norflurazon at 0.75 lb/A plus diuron applied preemergence and norflurazon applied PPI at 0.75 lb/A followed by norflurazon at 0.75 lb/A and diuron applied preemergence. Stand reductions were not found for any treatment in 1987 or 1989 (data not shown).

Moisture and temperature subsequent to application were similar in 1987 and 1988 (Table 1), however, injury response varied. Apparently, rainfall and the optimum growing conditions following emergence in 1988 maximized the crop-herbicide response so that simultaneous emergence and herbicide activation resulted in more injury.

In 1989, excess moisture and cool growing conditions delayed cotton emergence. Hypocotyl and radicle development of cotton is largely dependent upon interactions of temperature, moisture, and soil impedance (23). Wanjura and Buxton (23) reported that intermediate soil moisture regimes produced the longest radicle in cotton, and that a dramatic decrease in hypocotyl/radicle ratios occurred when soil moisture changed from 0.3 to 3.0 bars. In dry conditions, such as in 1987 and 1988, root mass increased more than in the extremely wet conditions in 1989. This and delayed emergence accounted in part for the reduced response in 1989 so that at 2 weeks after treatment, cotton injury was not apparent (data not shown). However, slight injury was noted at 4 weeks. This was in response to the delayed emergence experienced in 1989, as well as to the extremely wet conditions. Rate of water uptake of developing cotton seedlings has been shown to increase with higher temperatures and lower soil moisture tension (23). After the wet, cool conditions for 14 days following application in 1989, minimum soil temperatures at a 2-inch depth warmed from a 14-day preemergence average of 59°F to a 7-day postemergence of 66°F. Therefore, seedling development and subsequent herbicide absorption may have increased.

Seed cotton yields from all treatments were similar and better than the check in 1989 (Table 2). The highest yield in 1987 came from the norflurazon at 1.5 lb/A applied PPI and followed by diuron applied preemergence. Treatments with similar yields were norflurazon applied PPI at either 0.5 or 0.75 lb/A followed by norflurazon at equivalent rates tank-mixed with diuron applied PRE and the 0.5 or 1.0 lb/A rate of norflurazon applied PPI followed by diuron. All treatments increased seed cotton yields over that of the untreated control except for norflurazon applied preemergence at 1.5 lb/A. In general terms, when all or part of the norflurazon treatment was applied PPI, seed cotton yields were higher than when it was not.

Velvetleaf control with the norflurazon split at a total rate of 1.5 lb/A with diuron applied preemergence was better than 90% in all years at all timings (Table 3). However, this treatment resulted in crop

Table 2. Cotton phytotoxicity, cotton stand, and seed cotton yield following application of herbicides for preemergence velvetleaf control.[1]

Treatments			Cotton phytotoxicity				Cotton stand		
Method			2 weeks	4 weeks[2]			4 weeks	Seed cotton yield	
PPI	PRE	Rate	1988	1987	1988	1989	1988	1987	1989
		(kg/ha)	(%)					(kg/ha)	
Norflurazon		1.0	0 ef	0 e	0 e	0 b	54,230 ab	980 cde	1,440 a
Norflurazon		1.5	2 ef	0 e	0 e	0 b	58,150 a	1,230 b-e	1,390 a
Norflurazon	Norflurazon	0.5/0.5	6 def	0 e	0 e	0 b	55,210 a	1,010 cde	1,700 a
Norflurazon	Norflurazon	0.75/0.75	12 cde	0 e	0 e	0 b	57,500 a	1,100 b-e	1,710 a
	Norflurazon	1.0	12 de	0 e	0 e	0 b	55,380 a	920 cde	1,280 a
	Norflurazon	1.5	26 bc	0 e	10 cd	0 b	50,970 ab	640 ef	1,221 a
Norflurazon	Diuron	0.5/1.0	29 b	1 de	14 cd	2 b	45,410 a-d	1,350 a-d	1,610 a
Norflurazon	Diuron	0.75/1.0	16 cd	5 cde	4 de	11 a	53,270 ab	1,230 b-e	1,080 a
Norflurazon	Diuron	1.0/1.0	26 bc	11 abc	12 bcd	12 a	48,520 ab	1,470 abc	1,780 a
Norflurazon	Diuron	1.5/1.0	16 cd	8 abc	3 de	12 a	48,690 ab	1,900 a	1,560 a
	Norflurazon + Diuron	0.5 + 1.0	30 b	8 abc	8 abc	0 b	43,120 a-d	1,160 b-e	1,090 a
	Norflurazon + Diuron	0.75 + 1.0	45 a	9 abc	26 ab	0 b	33,160 cd	1,000 cde	1,330 a
	Norflurazon + Diuron	1.0 + 1.0	29 b	6 bcd	11 cd	0 b	51,960 ab	790 de	1,400 a
	Norflurazon + Diuron	1.5 + 1.0	48 a	12 ab	29 a	1 b	31,850 d	1,300 bcd	1,440 a
Norflurazon	Norflurazon + Diuron	0.5/0.5 + 1.0	30 b	15 a	14 abc	1 b	47,210 abc	1,400 a-d	1,830 a
Norflurazon	Norflurazon + Diuron	0.75/0.75 + 1.0	35 b	8 abc	17 abc	2 b	39,040 bcd	1,710 ab	1,540 a
Untreated Control		–	0 f	0 e	0 e	0 b	57,820 a	135 f	396 b

[1]Means within a column followed by the same letter are not significantly different according to DMRT (0.05).
[2]Analysis of variance conducted on transformed data.

injury greater than 25% and significant stand reductions in 1988 (Table 2). Decreasing the total rate to 1.0 lb/A maintained a similar level of control and did not reduce stand in 1988 but cotton injury was not alleviated.

In 1988, control at 2 weeks after application was similar for all treatments except norflurazon applied at 1.0 lb/A PRE (Table 3). However, control decreased over time and several differences in treatments were noted at 4, 6, and 8 weeks.

At 4 weeks, control with norflurazon applied at 1.0 or 1.5 lb/A PPI and followed by diuron PRE provided the most consistent control all 3 years (Table 3). These treatments were also less injurious initially than the norflurazon split/diuron combinations at equivalent rates (Table 2). However, cotton injury at 4 weeks was similar for each of these treatments. In 1987 and 1988, diuron applied PRE following either norflurazon applied at 1.5 lb/A PPI or PRE with diuron was better than norflurazon at 1.5 lb/A without diuron. This was also true of the 1 lb/A rate in 1988.

In 1989, norflurazon applied PPI at 1.0 or 1.5 lb/A and followed by diuron was better than norflurazon applied at 1.0 or 1.5 lb/A PPI, PRE, or with diuron as a PRE tank-mix. As previously mentioned, this treatment resulted in slight cotton injury (Table 2). Treatments that provided less than 85% control at 4 weeks in 1989 were norflurazon at 1 or 1.5 lb/A applied PPI, and norflurazon at 0.5 lb/A applied with diuron PRE. In general, rates of norflurazon applied at 0.5 lb/A PRE with diuron, norflurazon applied at 1.0 lb/A PPI, or norflurazon applied at 1.0 or 1.5 lb/A PRE were inconsistent. This will vary according to soil type. However, incorporating at least half of the norflurazon seemed to safeguard against adverse conditions and improved herbicide performance more consistently.

Direct comparisons of norflurazon-only treatments revealed no difference in any treatment combination at 6 weeks in 1987 (Figure 1). In 1988, incorporation of both rates of norflurazon improved velvetleaf control when compared to both rates applied PRE. Also, the norflurazon split applications were better than either full rate applied PRE.

Velvetleaf control at 6 weeks in 1987 was 94% when norflurazon was applied PPI at 1.5 lb/A and followed by diuron PRE (Table 3). This treatment was not prohibitively injurious. Reducing the rate to 1 lb/A or applying the norflurazon as a split with diuron was equally effective. However, by 8 weeks, the norflurazon split at a total rate of 1.0 lb/A with diuron was not as effective as the norflurazon PPI/diuron treatment when rates were 1.5 and 1.0 lb/A, respectively.

When uncultivated, norflurazon at 1.5 lb/A applied PPI, both norflurazon split/diuron combinations, and norflurazon at 1.0 or 1.5 lb/A applied PPI followed by

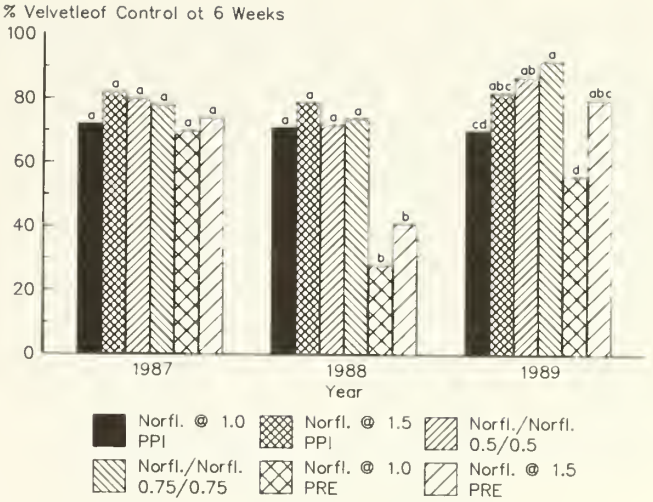

Figure 1. Influence of method of application of norflurazon (Norfl.) on velvetleaf control in cotton.

diuron provide similar control and were superior to most other treatments. In situations where the uncultivated control was less than 50%, such as preemergence application of norflurazon alone, and the 0.5-lb/A rate of norflurazon applied PRE with diuron, cultivation improved control significantly. When norflurazon was applied as a split with diuron, cultivation improved control if the total norflurazon rate was 1.0 but not for the 1.5 lb /A rate. Other treatments provided better than 70% control and were not improved by cultivation.

In 1989, treatment effects were optimized at 6 and 8 weeks by excessive rainfall throughout the season. Control varied little between the 6- and 8-week rating dates and indicated little response of velvetleaf control to cultivation. At 6 weeks, all treatments provided 80% or better control of velvetleaf except norflurazon applied PPI or PRE at 1.0 lb/A, and norflurazon applied at 0.5 or 1.0 lb/A plus diuron PRE.

Norflurazon applied PPI and followed by diuron provided the most consistent and effective control with only slight crop injury. At 6 weeks in 1987, application of 1.5 lb/A of norflurazon PPI followed by diuron was superior to the same norflurazon rate applied PRE with diuron (Figure 2). In 1988 and 1989, incorporation of norflurazon at 1.5 lb/A and followed by diuron provided better control than equivalent rates applied PRE. Generally, the same was true when comparing the 1.0 lb norflurazon rate similarly (Figure 3). However, in 1987 and 1988 the 0.5-lb and 0.75-lb rate did not provide control at 6 weeks comparable to that of the 1.5-lb rate applied PPI when all were applied in conjunction with diuron.

In conclusion, maximum crop injury occurred in

Table 3. Preemergence velvetleaf control in cotton.[1]

Treatment			Velvetleaf control				
Method			2 weeks[2]		4 weeks[3]		
PPI	PRE	Rate	1988	1989	1987	1988	1989
		(lb ai/A)	(%)				
Norflurazon		1.0	68 ef	77 d	78 e	70 cde	63 f
Norflurazon		1.5	74 de	85 cd	85 b-e	75 b-e	81 de
Norflurazon	Norflurazon	0.5/0.5	72 de	86 bcd	85 b-e	72 b-e	90 b-e
Norflurazon	Norflurazon	0.75/0.75	76 cde	98 abc	88 b-e	81 a-d	94 abc
	Norflurazon	1.0	56 f	95 abc	82 cde	40 f	82 cde
	Norflurazon	1.5	76 cde	97 abc	78 e	64 e	88 cde
Norflurazon	Diuron	0.5/1.0	84 a-d	98 abc	91 bcd	78 a-e	90 b-e
Norflurazon	Diuron	0.75/1.0	81 b-e	96 abc	89 b-e	85 ab	91 abc
Norflurazon	Diuron	1.0/1.0	95 ab	99 a	90 bcd	92 a	98 a
Norflurazon	Diuron	1.5/1.0	78 cde	96 abc	96 a	83 abc	97 ab
	Norflurazon + Diuron	0.5 + 1.0	75 cde	96 abc	89 bcd	66 de	79 e
	Norflurazon + Diuron	0.75 + 1.0	84 a-d	95 abc	81 de	75 b-e	86 cde
	Norflurazon + Diuron	1.0 + 1.0	81 b-e	99 a	87 b-e	77 b-e	86 cde
	Norflurazon + Diuron	1.5 + 1.0	89 abc	100 a	92 ab	82 abc	88 cde
Norflurazon	Norflurazon + Diuron	0.5/0.5 + 1.0	82 a-e	98 ab	93 ab	82 a-d	93 a-d
Norflurazon	Norflurazon + Diuron	0.75/ 0.75 + 1.0	97 a	96 abc	93 ab	91 a	94 abc
Untreated Control			0 g	0 e	0 f	0 g	0 g

[1]Means within a column followed by the same letter are not significantly different according to DMRT (0.05).
[2]14 DAT in 1988 and 10 DAT in 1989. No Transformation on data.
[3]Analysis of variance conducted on transformed data.

Treatments			Velvetleaf control					
			6 weeks					
Method			1988[3]				8 weeks[4]	
PPI	PRE	Rate	1987	Uncult.	Cult.	1989	1987	1989
		(lb ai/A)	(%)					
Norflurazon		1.0	72 f	71 cde	74 c-f	70 de	65 f	75 def
Norflurazon		1.5	82 b-f	79 abc	83 a-e	82 cd	76 de	83 bcd
Norflurazon	Norflurazon	0.5/0.5	80 c-f	72 b-e	78 b-e	87 bc	80 de	89 a-d
Norflurazon	Norflurazon	0.75/0.75	78 def	74 bcd	83 a-d	92 abc	81 de	85 bcd
	Norflurazon	1.0	70 f	28 g	44 gh	56 e	65 f	60 fg
	Norflurazon	1.5	74 ef	41 fg	59 fgh	80 cd	64 f	75 def
Norflurazon	Diuron	0.5/1.0	85 b-e	73 bcd	74 c-f	88 abc	82 cde	92 abc
Norflurazon	Diuron	0.75/1.0	82 c-f	77 bcd	84 a-d	95 ab	83 cde	99 a
Norflurazon	Diuron	1.0/1.0	88 a-d	90 a	92 a	96 a	91 ab	92 abc
Norflurazon	Diuron	1.5/1.0	94 a	88 ab	88 abc	98 a	95 a	97 ab
	Norflurazon + Diuron	0.5 + 1.0	82 b-f	42 fg	61 fg	68 de	79 de	65 ef
	Norflurazon + Diuron	0.75 + 1.0	82 b-f	58 ef	66 ef	80 cd	72 ef	78 def
	Norflurazon + Diuron	1.0 + 1.0	81 c-f	65 cde	70 def	79 cd	76 de	8 2 cde
	Norflurazon + Diuron	1.5 + 1.0	86 bcd	60 de	74 c-f	83 cd	85 bcd	88 a-d
Norflurazon	Norflurazon + Diuron	0.5/0.5 + 1.0	90 abc	80 abc	90 ab	97 a	86 bcd	96 abc
Norflurazon	Norflurazon + Diuron	0.75/0.75 + 1.0	92 ab	91 a	90 ab	97 a	90 abc	99 a
Untreated Control			0 g	0 h	41 h	0 f	0 g	42 g

[1]Means within a column followed by the same letter are not significantly different according to DMRT (0.05).
[2]Analysis of variance conducted on transformed data.
[3]LSD at (0.05) for uncultivated (Uncult) versus cultivated (Cult) within each treatment = 9.
[4]Eight-week ratings for 1989 are after one cultivation of the entire experiment. There was no cultivation in 1987.

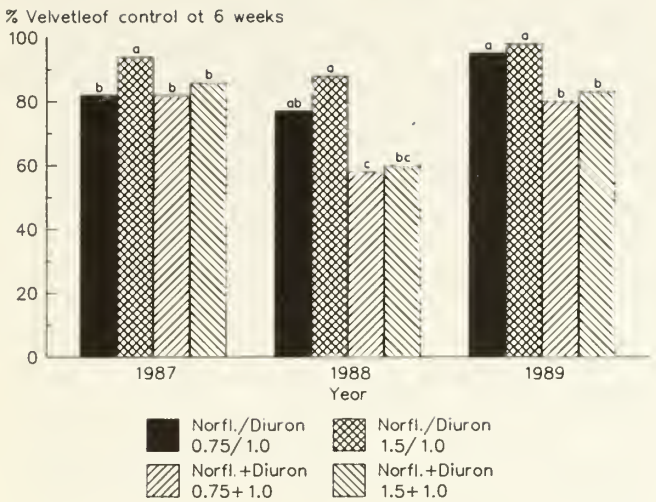

Figure 2. Influence of method of application on 0.75 lb/A and 1.0 lb/A norflurazon (Norfl.) rates in conjunction with diuron for preemergence velvetleaf control in cotton.

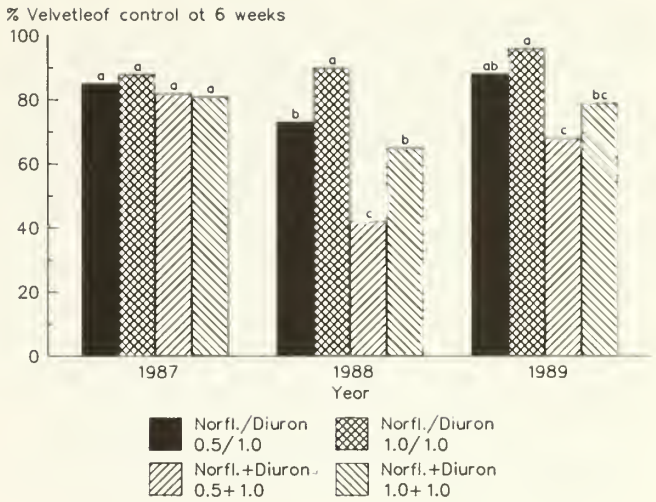

Figure 3. Influence of method of application on 0.5 lb/A and 1.0 lb/A norflurazon (Norfl.) rates in conjunction with diuron for preemergence velvetleaf control in cotton.

1988 when norflurazon was tank-mixed with diuron and applied preemergence. Applying norflurazon at either 1.0 or 1.5 lb/A PPI and following this with diuron at 1.0 lb/A provided the most reliable velvetleaf control with only slight crop injury.

Based on 1988 results, cultivation of these treatments did not improve control. When velvetleaf control was less than 50% without cultivation, control was improved significantly by cultivation. However, cultivation typically did not increase velvetleaf control for higher control ratings even though unacceptable infestation levels remained. One notable exception was the norflurazon split/diuron combination when the total norflurazon rate was 1.0 lb/A. Increasing the total split rate to 1.5 lb/A negated the need for cultivation.

Table 4. Cotton phytotoxicity and cotton stand following application of various herbicides for preemergence control of common cocklebur.[1]

Treatments			Crop Injury			Cotton stand
Method of Application		Rate	2 weeks	4 weeks		4 weeks
PPI	PRE	lb ai/A	1988	1987	1988	1988
				(%)		No./A
–	Fluometuron	1.5	0 h	0 c	0 b	51,670 a
–	Norflurazon	1.5	16 cd	0 c	5 b	47,740 ab
–	Diuron	1.0	6 fgh	10 ab	0 b	47,740 ab
Norflurazon	–	1.5	0 h	0 c	0 b	52,320 a
Norflurazon	Norflurazon	0.75/0.75	11 def	0 c	2 b	52,320 a
Norflurazon	Fluometuron	0.75/1.5	2 gh	0 c	0 b	56,240 a
Norflurazon	Diuron	0.75/1.0	9 efg	8 b	1 b	51,610 a
Norflurazon	Fluometuron	1.5/1.5	0 h	0 c	0 b	51,670 a
Norflurazon	Diuron	1.5/1.0	9 d-g	10 ab	2 b	51,670 a
Norflurazon	Norflurazon + Fluometuron +	0.75/0.75 1.5	14 cde	0 c	5 b	56,900 a
Norflurazon	Norflurazon + Diuron +	0.75/0.75 1.0	30 b	9 ab	19 a	39,890 bc
–	Norflurazon + Fluometuron	1.5 + 1.5	20 c	0 c	6 b	52,320 a
–	Diuron + Fluometuron	1.0 + 1.5	35 ab	11 ab	20 a	38,590 bc
–	Norflurazon + Diuron	1.5 + 1.0	30 b	13 a	19 a	35,320 cd
–	Norflurazon + Diuron + Fluometuron	1.5 + 1.0 1.5	38 a	13 a	25 a	26,160 d
Untreated			0 h	0 c	0 b	56,240 a

[1]Means within columns followed by the same letter are not significantly different at the 5% level of probability according to DMRT.

Common Cocklebur

In 1988, the three-way tank-mix combination of norflurazon, diuron, and fluometuron caused the most injury (Table 4). A tank-mix combination of diuron plus fluometuron was similar. As in the velvetleaf study, injury appeared more severe when diuron was tank-mixed with norflurazon and applied PRE. At 4 weeks, injury was 25% or less for all treatments. However, all preemergence tank-mixes containing diuron caused more injury than any other treatment evaluated. At 4 weeks after treatment, diuron applied alone as a preemergence application resulted in no injury. However, diuron combined with fluometuron or norflurazon caused injury in the 20 to 25% range with 25% injury resulting in a three-way tank-mix of the three compounds.

In addition to crop injury, stand counts made at 4 weeks after treatment indicated that stands were reduced by treatments that contained diuron as part of the preemergence tank-mix (Table 4). Although each component when applied alone did not reduce stands, combining norflurazon or fluometuron with diuron and applied preemergence reduced stands below that of the untreated check. Further stand reductions were caused by a three-way tank-mix of all compounds evaluated. A two-way tank-mix of norflurazon plus fluometuron applied preemergence did not reduce stands when compared to the check and was similar to those treatments showing no crop injury. In 1987, crop injury at 4 weeks after treatment was less than 15% for all treatments evaluated. Diuron and all combinations including diuron resulted in injury greater than that of the untreated check. However, injury did not exceed 15%. The same was the case in the velvetleaf study. However, the velvetleaf study did not include a treatment with diuron applied alone. The 10% crop injury reported for diuron when applied PRE alone indicated that diuron was the primary component causing crop injury in 1987. This is supported further by the fact that when fluometuron or norflurazon were applied alone as PRE, no crop injury resulted. However, injury from diuron in 1988 was not apparent unless it was tank-mixed with norflurazon or fluometuron and applied PRE.

Overall, common cocklebur control was better in 1987 than in 1988 (Table 5). Common cocklebur populations were three times higher in 1988 than in 1987. This, in part, accounts for the reduced control in 1988, since the overall abundance of common cocklebur provided a larger population that was in some way less susceptible to chemical treatment.

In 1987, at 4 weeks after herbicide application, all treatments evaluated provided better than 75% common cocklebur control. The three-way tank-mix of norflurazon, diuron, and fluometuron applied preemergence provided 97% control. However, this was the most injurious treatment evaluated during the 2-year study. Other treatments that compared favorably but were less injurious were: (1) norflurazon applied PPI at 0.75 or 1.5 lb/A followed by fluometuron applied PRE; (2) the norflurazon split at a total rate of 1.5 lb/A with fluometuron included in the preemergence application; and (3) norflurazon at 1.5 lb/A applied as a tank-mix with fluometuron applied PRE. As previously stated, most diuron treatments resulted in crop injury during the course of study. However, in 1987, norflurazon applied PPI at 1.5 lb/A followed by diuron PRE provided 93% control and injury did not exceed 10%. In 1988, this treatment was one of the few diuron treatments that did not adversely affect cotton stand.

At 6 weeks after treatment in 1987, norflurazon applied PPI at 1.5 lb/A followed by fluometuron applied PRE was the superior treatment. The only other treatment that compared favorably to this was the three-way tank-mix combination. However, as previously stated, this treatment reduced stand in 1988 and was more injurious than other treatments in 1987. Norflurazon applied PPI at 1.5 lb/A followed by fluometuron PRE provided 94% control at 8 weeks after treatment. All other treatments other than the three-way tank-mix combination were significantly less than this and control did not exceed 82%. In 1987, norflurazon applied PPI at 1.5 lb/A followed by fluometuron applied PRE was the best treatment for common cocklebur control and did not result in any crop injury or stand reduction.

In 1988, common cocklebur control at 2 weeks after treatment did not exceed 81% for any treatment evaluated (Table 5). The three-way tank-mix was the superior treatment but resulted in excessive injury and significant stand reduction (Table 4). Other treatments that provided better than 70% common cocklebur control were norflurazon applied PP I at 1.5 lb/A followed by fluometuron applied PRE; a norflurazon split, which included diuron in the preemergence half; a diuron plus fluometuron tank-mix applied PRE; or a norflurazon/diuron tank-mix applied PRE. However, the latter two treatments reduced cotton stand below that of the untreated check.

At 4 weeks after treatment in 1988, norflurazon applied PPI at 1.5 lb/A followed by fluometuron applied PRE provided the highest percent common cocklebur control and did not result in any crop injury or stand reduction (Tables 4 and 5). Control for this treatment in 1988 was only 57%, but was 96% in 1987. In 1988, other treatments provided higher control ratings but injury was greater. For the 2 years of evaluation, norflurazon applied PPI at 1.5 lb/A followed by

fluometuron applied PRE resulted in the highest percent common cocklebur contro l with the least amount of crop injury.

Cultivation resulted in a significant improvement in common cocklebur control (Table 5). In the velvetleaf experiment, cultivation improved control only for certain treatments and in general provided improved control only when initial velvetleaf control was less than 50%. For the common cocklebur experiment, uncultivated common cocklebur control at 6 weeks after treatment did not exceed 48%. The addition of cultivation significantly improved control for all treatments. However, it is important to note that cultivation of the untreated check provided 40% common cocklebur control. Although all treatments in the uncultivated plots were less than 50%, the addition of cultivation did not improve control to acceptable levels and in most cases did not exceed that of the untreated control. This reinforces the concept that effective preemergence herbicides are the foundation to sound weed-management programs, and these programs cannot rely solely on cultivation to achieve optimum control. This was particularly true for common cocklebur control.

Literature Cited

1. Baldwin, F. L., and W. E. Woodall. 1977. Weeds in cotton–the Midsouth. Beltwide Cotton Production Res. Conf. 1977, p. 160-161.
2. Boyette, C. D., and H. L. Walker. 1985. Evaluation of *Fusarium lateritium* as a biological herbicide for controlling velvetleaf *Abutilon theophrasti* and prickly sida *Sida spinosa.* Weed Science 34 :106-109.
3. Buchanan, G. A., and E. R. Burns. 1971. Influence of weed competition on cotton II. Cocklebur and redroot pigweed. Weed Science 19:580-582.
4. Buchanan, G. A., and E. R. Burns. 1970. Influence of weed competition on cotton. Weed Science 18:149-154.
5. Byrd, J. D., Jr. 1990. Report of the cotton weed loss committee. Beltwide Cotton Production Res. Conf. 1989, (in press).
6. Chandler, J. M. 1977. Competition of spurred anoda, velvetleaf, prickly sida, and Venice mallow in cotton. Weed Science 25:151-158.
7. Cooley, A. W., and D. T. Smith. 1974. Weed and herbicide research in West Texas. 1971-1973. Consol. Prog. Rep. Texas Agric. Exp. Stn. p. 11-14.
8. Elmore, C. D. 1989. Weed survey - southern states. Proc. South. Weed Science Soc. 42:408-411.

Table 5. Preemergence common cocklebur control in cotton.

Treatments			Common Cocklebur Control [1,2]						
Method of Application		Rate	2 weeks	4 weeks			1988[3]		6 weeks
PPI	PRE	lb ai/A	1988	1987	1988	1987	Uncult	Cult	8 weeks 1987
			(%)						
–	Fluometuron	1.5	50 ef	88 c	14 fg	78 d	21 c-f	48 bc	75 b-e
–	Norflurazon	1.5	60 cde	77 d	20 efg	58 ef	12 fg	40 c	35 f
–	Diuron	1.0	39 f	78 d	19 efg	48 g	11 fg	41 c	42 f
Norflurazon	–	1.5	51 ef	88 bc	34 c-f	66 e	18 ef	49 bc	62 e
Norflurazon	Norflurazon	0.75/0.75	56 de	77 d	24 ef	56 fg	16 ef	46 bc	42 f
Norflurazon	Fluometuron	0.75/1.5	58 de	94 abc	30 def	89 b	21 c-f	45 bc	82 bc
Norflurazon	Diuron	0.75/1.0	64 b-e	88 bc	39 b-e	76 d	36 abc	59 a	70 cde
Norflurazon	Fluometuron	1.5/1.5	73 abc	96 a	57 ab	94 a	48 a	60 a	94 a
Norflurazon	Diuron	1.5/1.0	56 de	93 abc	36 b-f	81 cd	35 abc	51 ab	79 bcd
Norflurazon	Norflurazon + Fluometuron +	0.75/0.75 1.5	68 a-d	94 ab	40 b-e	88 b	34 a-d	45 bc	84 b
Norflurazon	Norflurazon + Diuron +	0.75/0.75 1.0	74 ab	92 abc	65 a	75 d	38 ab	46 bc	70 cde
–	Norflurazon + Fluometuron	1.5 + 1.5	66 bcd	92 abc	38 b-e	85 bc	30 b-e	46 bc	82 bc
–	Diuron + Fluometuron	1.0 + 1.5	76 ab	95 ab	56 abc	86 bc	20 def	46 bc	80 bc
–	Norflurazon + Diuron	1.5 + 1.0	70 a-d	92 abc	48 a-d	76 d	26 b-f	49 bc	65 de
–	Norflurazon + Diuron + Fluometuron	1.5 + 1.0 1.5	81 a	97 a	65 a	90 ab	39 ab	54 ab	87 ab
Untreated			0 g	0 e	0 g	0 h	0 g	40 c	0 g

[1]Means within columns followed by the same letter are not significantly different at the 5% level of probability according to DMRT.
[2]Analysis performed on transformed data at 6 and 8 weeks in 1987 only.
[3]LSD (0.05) for comparison of uncultivated (Uncult) vs cultivated (Cult) within each treatment = 9.

9. Elmore, C. D. 1980. Inhibition of turnip (*Brassica rapa*) seed germination by velvetleaf (*Abutilon theophrasti*) seed. Weed Sci. 28:658-660.

10. Frans, R. 1980. Usage and spectrum of weeds controlled by phenylurea herbicides. Beltwide Cotton Production Res. Conf. 1980, p. 170-174.

11. Gressel, J. B., and L. G. Holm. 1964. Chemical inhibition of crop germination by weed seeds and the nature of inhibition by *Abutilon theophrasti*. Weed Research 4:44-53.

12. Hayes, R. M., and P. E. Hoskinson. 1983. Performance of new herbicides for weed control in cotton. 1983 Beltwide Cotton Production Res. Conf., p. 251.

13. Higgins, J. M., R. H. Walker, and T. Whitwell. 1986. Coffee senna (*Cassia occidentalis*) competition with cotton (*Gossypium hirsutum*). Weed Science 34:52-56.

14. Holsten, J. T., Jr. 1963. Cultivation techniques in combination with chemical weed control in cotton. Weeds 11:191-194.

15. Mueller, T. C., and W. W. Witt. 1987. The effect of planting date on flowering of cotton, jimsonweed, and velvetleaf. Proc. South. Weed Sci. Soc. 40:301.

16. Lueschen, W. E., and R. N. Anderson. 1980. Longevity of velvetleaf (*Abutilon theophrasti*) seeds under agricultural practices. Weed Science 28:341-346.

17. Ridgway, R. L., A. A. Bell, J. A. Veech, and J. M. Chandler. 1984. Cotton protection practices in the USA and world. p. 265-365 in R. J. Kohel and C. F. Lewis, eds. Cotton. Agronomy Monograph No. 24. ASA-CSSA-JSSA, Madison, WI.

18. Smith, B. S., and D. S. Murray. 1989. Interference of velvetleaf (*Abutilon theophrasti*) with cotton (*Gossypium hirsutum*). Proc. South. Weed Sci. Soc. 42:280.

19. Snipes, C. E., J. E. Street, and R. H. Walker. 1987. Interference periods of common cocklebur (*Xanthium strumarium*) with cotton (*Gossypium hirsutum*). Weed Science 35:529-532.

20. Snipes, C. E., R. H. Walker, T. Whitwell, G. A. Buchanan, J. A. McGuire, and N. R. Martin. 1984. Efficacy and economics of weed control methods in cotton (Gossypium hirsutum). Weed Science 32:95-100.

21. Snipes, C. E. , G. A. Buchanan, J. E. Street, and J. A. McGuire. 1982. Competition of common cocklebur (*Xanthium pensylvanicum*) with cotton (*Gossypium hirsutum*). Weed Science 30:553-556.

22. Thornton, N. C. 1935. Factors influencing germination and development of dormancy in cocklebur seeds. Contrib. Boyce Thompson Inst. 7:477-496.

23. Wanjura, D. F., and D. R. Buxton. 1972. Hypocotyl and radicle elongation of cotton as affected by soil environment. Agron. J. 64:453-434.

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